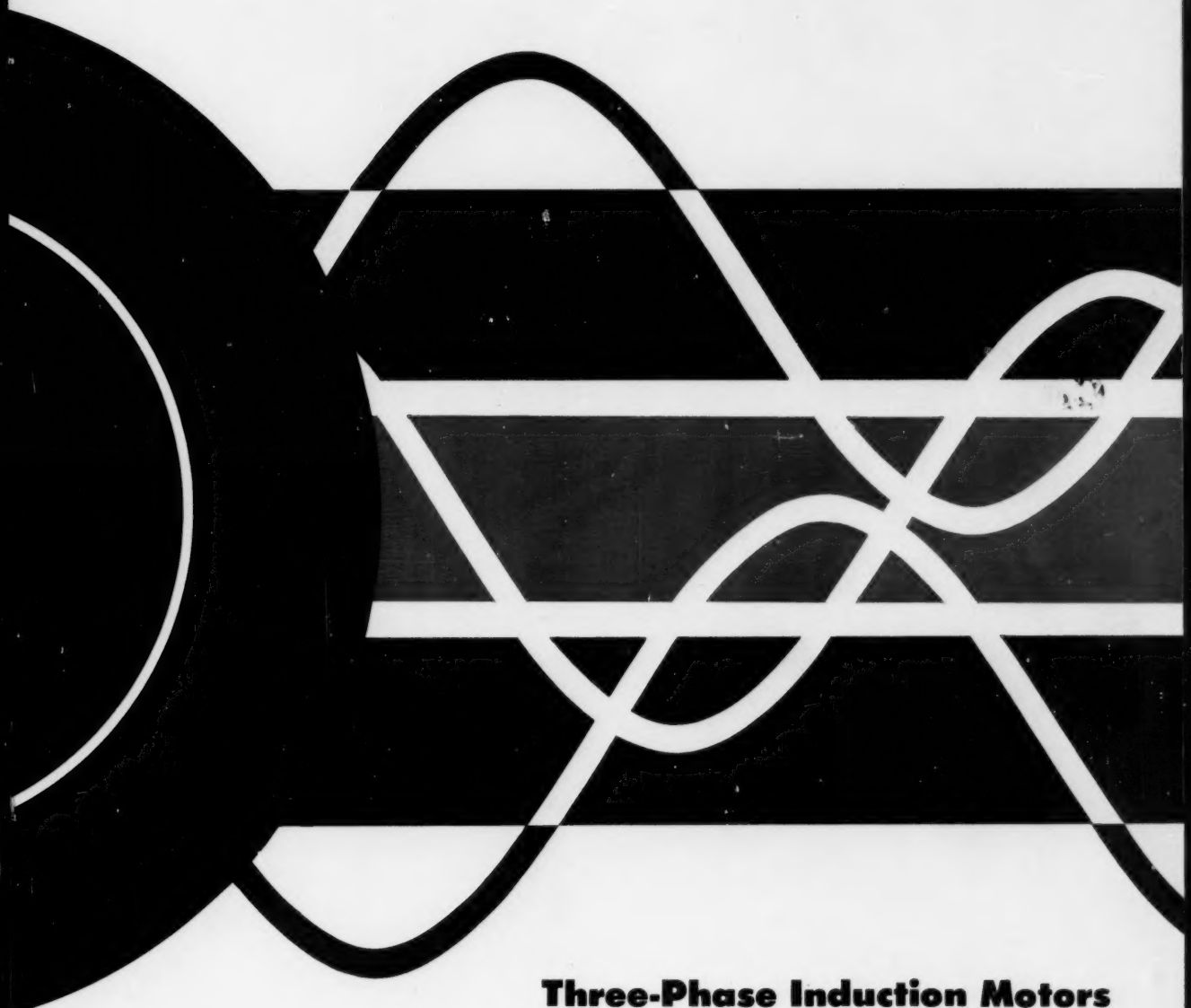
JUNE 25, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Three-Phase Induction Motors

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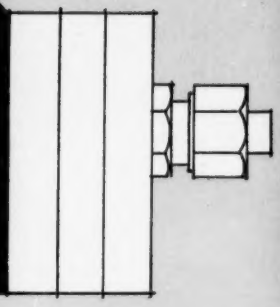
ARNOWORTH

off-the-shelf pumps just right for your requirements



Whatever you want in a pump – for hydraulics, for flow or process control, there is likely to be an Eastern ready-made unit . . . made-to-order for your needs.

CAN YOU USE THESE PUMP FEATURES:

- ☐ corrosion resistant construction for chemical solutions?
- ☐ ability to handle organic and inorganic fluids at various temperatures with flows up to 70 GPM, pressures to 65 psig?
- ☐ available with open, enclosed or explosion proof motors?
- ☐ compact lightweight units with or without motor?
- ☐ high efficiencies in handling hydraulic oil, fuel and lubricants at high pressures?
- ☐ flow rates from 0.1 to 9.8 GPM, pressures from 0 to 1500 PSI?
- ☐ self-priming operation with non-lubricating liquids?
- ☐ high pressure outputs with small, low power units... and no contamination of fluid?
- ☐ flow rates from ½ GPM to 5½ GPM, pressures from 30 to 200 PSI?

An EASTERN CENTRIFUGAL PUMP MIGHT BE JUST RIGHT FOR YOU!

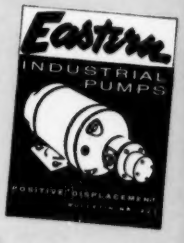
Write for Bulletin 120.

Look into EASTERN HYDRAULIC PUMPS!

Write for Bulletin 810

Get to know more about EASTERN POSITIVE DISPLACEMENT PUMPS!

Write for Bulletin 220.



These useful brochures contain full specifications on the complete line in each category, including performance data and tables. They will be sent to you at no obligation whatever. Write Department R.

EASTERN INDUSTRIES, INC.

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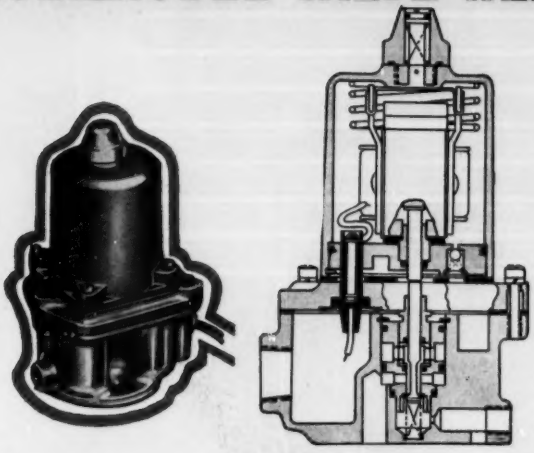
a basic Ross valve building block

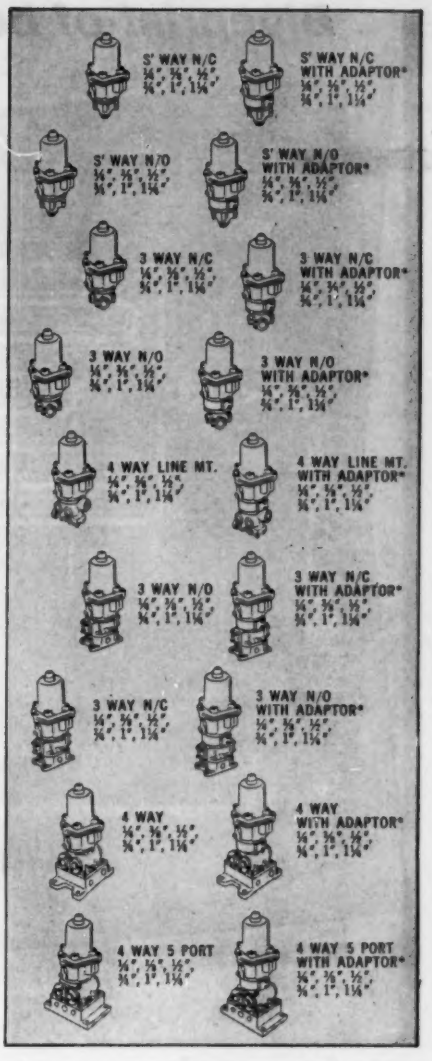
GOLDMODEL VALVE HEAD



OIL IMMERSED SOLENOID

- The finest achievement in solenoid heads
- JIC
- Over 50 million cycles in tests
- Lightning fast

Modular construction is brought to the air valve field to give you the effect of a great valve inventory without stocking a great number of valves. Stock just one of these Goldmodel heads and you have the finest solenoid actuator obtainable for any one of the 54 Skyline bodies. This is the head designed especially for those uses where dependable performance and very long life must supersede all other considerations. The dustproof solenoid is the very finest and is immersed in oil to run cool and stay young. Write for bulletin 318.


5 WAY N/C
5 WAY N/C WITH ADAPTOR*
5 WAY N/O
5 WAY N/O WITH ADAPTOR*
3 WAY N/C
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4 WAY LINE MT.
4 WAY LINE MT. WITH ADAPTOR*
3 WAY N/O
3 WAY N/C WITH ADAPTOR*
3 WAY N/C
3 WAY N/O WITH ADAPTOR*
4 WAY
4 WAY WITH ADAPTOR*
4 WAY 5 PORT
4 WAY 5 PORT WITH ADAPTOR*

"every head meets every body at this gasket"

ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES

STRAIGHTWAY NORMALLY OPEN NORMALLY CLOSED
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
4 WAY 5 PORT

STAY AHEAD

MODERNIZE

ROSS OPERATING VALVE COMPANY

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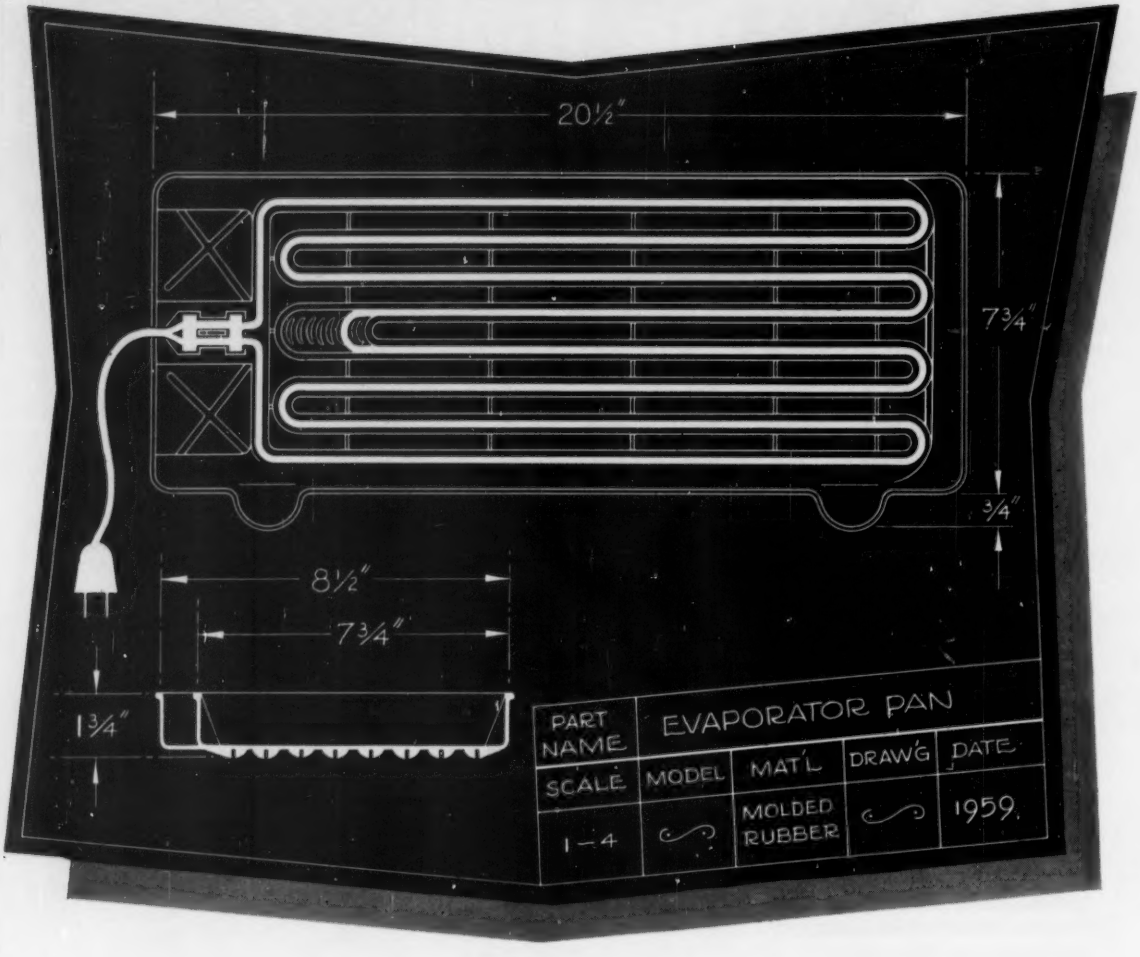
Blueprint of better design–



–for an improved refrigerator evaporator pan

To Goodyear molded/extruded rubber specialists, the problem was typical: Develop an evaporator pan that wouldn't rattle–one that would last longer and heat more efficiently than the pans of other materials and with separate heaters then in use.

The results of the project exceeded the hopes of the big-name refrigerator maker. For the new molded rubber pan developed by Goodyear is rattleproof, rustproof, virtually indestructible. What's more, its special bottom grooving accommodates a snap-in heating unit offering one-piece compactness–plus easy removal for replacement.

So once again the skilled personnel – in the modern Goodyear molded/extruded plants – have made an important contribution to modern product design. It's a sample of what *you* can expect when you call on some of the country's outstanding rubber specialists at Goodyear.

For complete information – or an invitation to tour these plants and see their unparalleled facilities for yourself, contact your G.T.M.–Goodyear Technical Man. Or write directly to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED OR EXTRUDED RUBBER BY

GOODYEAR

THE GREATEST NAME IN RUBBER

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Front Cover: Three electric-power phases fed into a motor symbol are used by artist George Farnsworth to highlight C. H. Buchanan's article on three-phase induction motors beginning on Page 107 of this issue.

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MACHINE DESIGN

June 25, 1959
Volume 31 — No. 13

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BENJAMIN L. HUMMEL—*Editorial*

Engineering News 6
Vacuum tube stand-in points out chassis hot spots—malleable iron proves out in 800 to 1200 F service—catalysts and cooler upgrade lift-truck exhausts—ASEE head says falling engineering enrollment threatens living standards—microtome cuts 75-angstrom slices by magnetostriction—beryllium heat sink cools Mercury capsule—peroxide turbines control deadstick X-15—iodine-cycle lamp has self-cleaning action.

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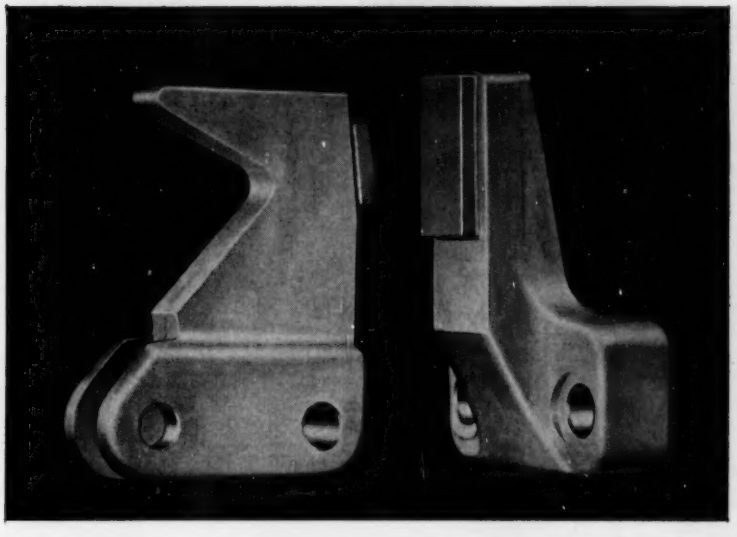
Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

TWICE-WROUGHT METAL

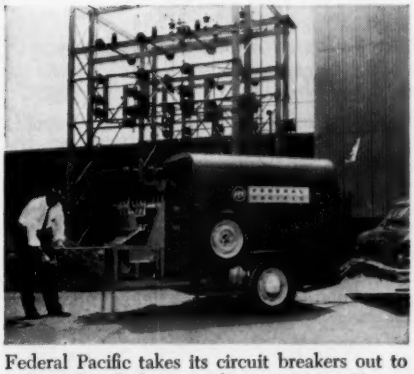
of die-pressed forgings helps Federal Pacific make new air circuit breakers more rugged—cuts machining costs in half



In its new Type DST magnetic air circuit breaker line, Federal Pacific Electric Company, Newark, N. J., builds in dependable operation and long life with parts of outstanding mechanical and adequate electrical properties.

Typical of this attention to detail are the arcing contacts (left). Similar parts previously used had been castings or built-up assemblies. Now the contact bodies are Anaconda Forging Brass-250 die-pressed forgings. The twice-wrought metal is denser, stronger, withstands mechanical shock better—reducing the fatigue factor and producing longer service life. The contacts also have higher conductivity. And best of all, their consistent dimensional accuracy and smooth finish cut machining costs in half.

RIGHT: Movable arcing contact assemblies at the left and the stationary arcing contact assemblies at the right in a 5-kv Federal Pacific Type DST air circuit breaker. They have a momentary current-carrying capacity of 60,000 amperes. Contact tips of tungsten alloy are silver-soldered to the forgings. These are two of several areas where Federal Pacific uses the superior physical properties of Anaconda die-pressed forgings to help provide dependable operation and long service life in its line of metal-clad switchgear.



Federal Pacific takes its circuit breakers out to industrial and electric utility customers. Here a representative sets up a demonstration of a 5-kv, 1,200-amp breaker in the field.

IT IS often easier than you think to achieve high quality and performance while simplifying fabrication and cutting over-all costs. American Brass technical specialists are constantly working with designers, production engineers and buyers, helping them meet their joint requirements—through the use of such Anaconda mill products as die-pressed forgings, extruded shapes, special-shape tubes. For this kind of practical help, see your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Toronto 14, Ontario. B944

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ENGINEERING NEWS

Drop in Engineering Enrollment Threatens Standard of Living

ASEE President Contrasts Trends In Population and New Students

BOSTON—The fizzle in engineering enrollment, at a time when the U. S. is experiencing a "population explosion," points to a coming drop in the American standard of living, according to William T. Alexander, Dean of the College of Engineering of Northeastern University.

Retiring as president of the American Society for Engineering Education, Dean Alexander told members of the society that the estimated U. S. population of 350 million by the year 2000 means "that there will be enormous needs for goods and services requiring competent engineers. Hence the supply of professionally educated engineers must at least keep pace with our population growth, and at present there is no evidence to indicate that this will happen. As a matter of fact, the evidence at present shows the engineering trend going in the opposite direction."

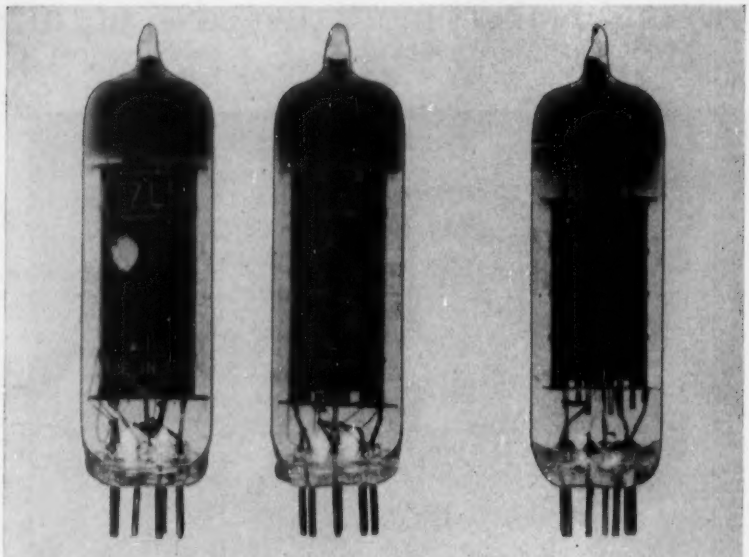
Last fall, when freshman enrollment was 7 per cent higher than in 1957, the number of new engineering students was down 11 per cent. Total engineering enrollment (graduate and undergraduate) dropped 2.5 per cent; total undergraduate engineering enrollment fell 4.5 per cent. A comparison with the situation in Russia shows two and a half times as many engineering graduates a year there as in the U. S.

Dean Alexander offered four probable reasons for the drop in engineering enrollment:

- Wide publicity given to engineering layoffs and reported scarcity of jobs for new graduates.
- Rumors that engineering studies are more difficult than they actually are.
- Increased interest by potential engineering students in other fields, especially science. Frequently this diversion is the result of misinformation or lack of understanding of the different characters of science and engineering.
- Raised admission requirements to colleges of engineering.

Another possible deterrent to engineering enrollments is the false idea that engineering study is "narrow" and highly specialized. Dean Alexander says this is not so and that engineering education is "an excellent preparation for life."

He feels that in this scientific age an engineering education should be regarded in much the same way as a liberal-arts, broad-background type of education. It is a sound general education as well as preparation for a professional career.



Thermal analogue tubes Vacuum tube

Stand-in for Vacuum Tubes Points Out Hot Spots

Potential overheating of electronic-chassis tubes and hardware is predicted at the breadboard stage by a unique thermal-analogue tube. Called the Thermion, the new test device is physically and thermally identical to any vacuum tube in its size class. Thermocouples built into the stand-in unit permit accurate estimation of anode and bulb temperatures before construction of a prototype circuit. Developers of Thermion, Research Council Inc., Waltham, Mass., point out that it permits the chassis designer to thermally optimize layout of components, hardware, and enclosures. Thermion will be built in 10 sizes for simulating up to 80 standard and miniature vacuum tubes.

Electrons Shield Latest U. S. Bomber

Countermeasures Will Delay, Confuse, Deny Enemy Attack

PITTSBURGH — An electronic shield will protect the Air Force B-70 Valkyrie intercontinental bomber from enemy attack.

Award of a multimillion dollar contract was announced by Raymond H. Rice, North American Aviation Inc., B-70 weapon-system contractor, and Dr. Patrick Conley, Westinghouse Electric Corp., subcontractor for the shield.

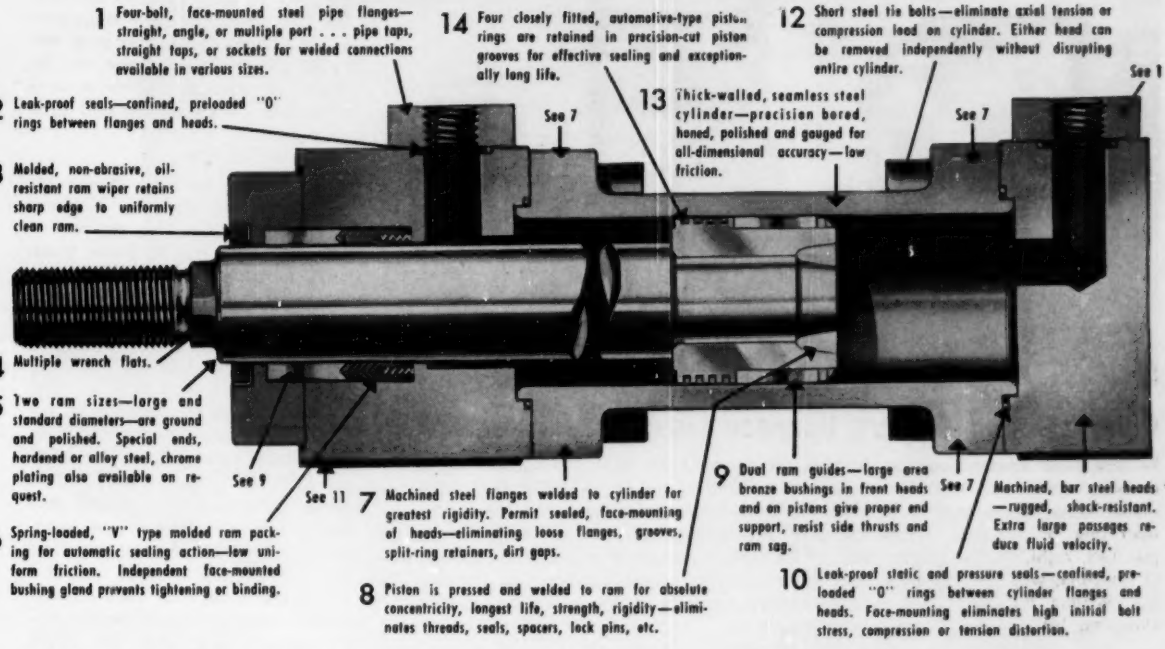
"The defensive system will make use of electromagnetic and other

Circle 407 on Page 19→

. . . Fluid Power news

3,500 psi HEAVY-DUTY CYLINDERS

✓ Check . . . Compare these 20 advantage-features of Oilgear's "Custom-Quality", Heavy-Duty, 3,500 psi Cylinder Line


1 Four-bolt, face-mounted steel pipe flanges—straight, angle, or multiple port . . . pipe taps, straight taps, or sockets for welded connections available in various sizes.
2 Leak-proof seals—confined, preloaded "O" rings between flanges and heads.
3 Molded, non-abrasive, oil-resistant ram wiper retains sharp edge to uniformly clean ram.
4 Multiple wrench flats.
5 Two ram sizes—large and standard diameters—are ground and polished. Special ends, hardened or alloy steel, chrome plating also available on request.
6 Spring-loaded, "V" type molded ram packing for automatic sealing action—low uniform friction. Independent face-mounted bushing gland prevents tightening or binding.
7 Machined steel flanges welded to cylinder for greatest rigidity. Permit sealed, face-mounting of heads—eliminating loose flanges, grooves, split-ring retainers, dirt gaps.
8 Piston is pressed and welded to ram for absolute concentricity, longest life, strength, rigidity—eliminates threads, seals, spacers, lock pins, etc.
9 Dual ram guides—large area bronze bushings in front heads and on pistons give proper end support, resist side thrusts and ram sag.
10 Leak-proof static and pressure seals—confined, preloaded "O" rings between cylinder flanges and heads. Face-mounting eliminates high initial bolt stress, compression or tension distortion.
11 Machined, bar steel heads—rugged, shock-resistant. Extra large passages reduce fluid velocity.
12 Short steel tie bolts—eliminate axial tension or compression load on cylinder. Either head can be removed independently without disrupting entire cylinder.
13 Thick-walled, seamless steel cylinder—precision bored, honed, polished and gauged for all-dimensional accuracy—low friction.
14 Four closely fitted, automotive-type piston rings are retained in precision-cut piston grooves for effective sealing and exceptionally long life.
See 1
See 7
See 7
See 7
See 9
See 11

15 Adjustable hydraulic cushions—dash pots—for front, rear, or both heads. New, exclusive Oilgear floating-sleeve design assures superior performance, longer life, less wear—eliminates check valves.

16 Eight basic sizes—2", 2½", 3¼", 4", 5", 6", 7", 8" . . . length of stroke varies from 36" to 158". Longer stroke available on request.

17 Air vent plugs, double end rams, special ram ends, special packings for use with fire-resistant fluids are also available.

18 Choice of fixed mountings—foot lug, center lug, or flange—can be combined or interchanged, front or rear, to suit any requirement.

19 Choice of hollow trunnion mountings—rear, center, front—accurately machined, integral with heads. No hoses or slide joints—Oilgear's exclusive steel flange connectors—rugged, leak-proof, rotate smoothly.

20 Designed and built to the highest standard of quality for the most dependable, trouble-free, long life. Machinery builders and users alike, say—"For the lowest cost per year—it's Oilgear!"

STANDARD MOUNTINGS

Front and rear foot lug mounting
Front and rear center lug mounting
Heads can be combined or interchanged
Rear flange mounting plain front head
Front flange mounting plain rear head
Rear trunnion mounting plain front head
Front trunnion mounting plain rear head (not shown)
Center trunnion mounting, plain front and rear heads

Complete user satisfaction is guaranteed by Oilgear's extensive research, testing, over 35 years of design, manufacturing, and application experience in the field of Fluid Power —both oil and fire-resistant fluids.

For further information on these new cylinders, call your Oilgear Application-Engineer. Or write for bulletins 73000 and 73245 directly to . . .

THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

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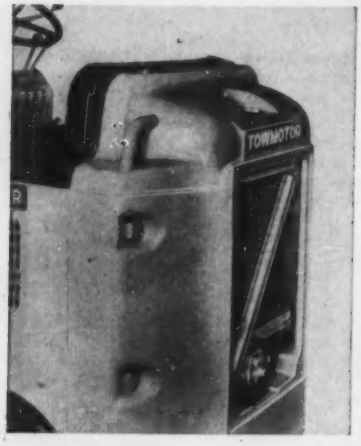
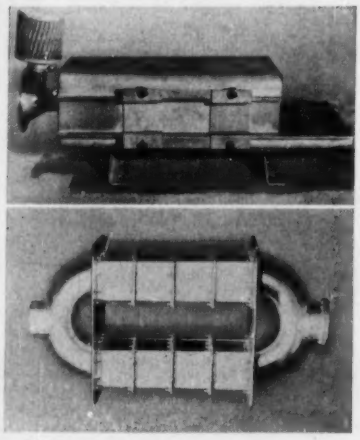
techniques to make it difficult if not impossible for enemy aircraft or missiles to successfully attack the B-70," Mr. Rice said. "This system with its advanced technical developments will greatly increase the manned aircraft's capacity of self defense . . . The defensive system provides the Strategic Air Command bomber crew with a bag of tricks to further confuse the enemy."

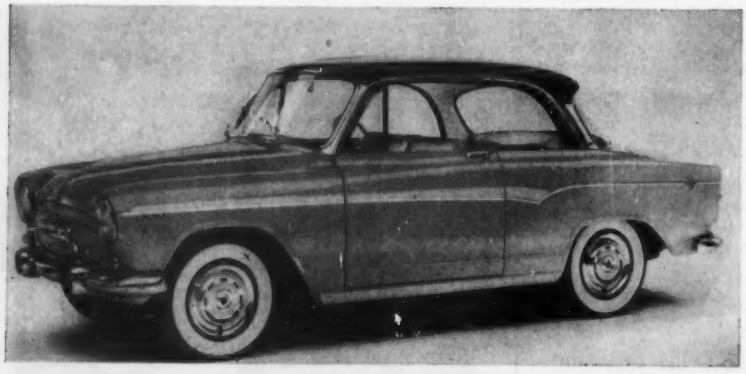
Dr. Conley explained that the B-70's defense will involve electronic countermeasures to "delay, confuse, distort and even deny enemy intelligence." Design of the highly sophisticated system may require several years of research and development, says Westinghouse.





Catalysts and Coolers Upgrade Lift-Truck Exhausts

Exhaust flow directed against the radiator and into the fan airstream dissipates backfire sparks and flame in a new safety exhaust system for lift trucks. Towmotor Corp., Cleveland, developed the Cool-Flow system, left, for use on its own line of vehicles. Further exhaust improvement is provided by catalytic purifiers, right, that eliminate most of the carbon monoxide and other impurities in gasoline, LPG, and diesel-engine exhaust. Purifiers, developed by Oxy-Catalyst Inc., Wayne, Pa., and the cooling system were displayed at the recent Materials Handling Institute Exposition in Cleveland.



Latest Paris Auto Fashion

Grand Lark hardtop (shown) and Elysee sedan are the latest of Simca line handled by Chrysler. These two models will be offered in Chrysler product showrooms starting June 26. The two models pioneer several innovations in the line: A curved panoramic windshield, together with a wrap-around rear window give 30 per cent more glass area; a spare tire stored under the trunk permits more luggage area; an improved four-speed forward transmission offers smoother and quieter rides. Simca's four-cylinder, 48-hp engine powers both models.

Topics

A stardust operation that probably never occurred to Hoagy Carmichael will be undertaken by an Aerobee rocket this fall. Sponsored by the Air Research and Development Command, the rocket will be fired about 150 miles into space and, if all goes well, will bring back samples of space debris. Scientists know that outer space is cluttered with billions of tiny micro-meteorite particles, but they seek to determine the composition of the particles, what they look like, how fast they travel, and how many exist in given areas. Such information will permit informed speculation on the effects of stardust (which actually comes from comets and the sun) upon space ships.

• • •

Atomic war on lawn disease has conquered stem rust in bluegrass. Neutrons were shot into the seed to produce a basic genetic change which makes the grass resistant to the malady. Botanists hope to use the same method to effect changes in other domestic plants and farm crops, thereby saving years of cross-breeding.

• • •

Coziest foxhole ever made is a product of the plastics industry. Stafoam, a urethane foam made by American Latex Products Corp., recently was demonstrated to Army personnel as a liner which will insulate and waterproof foxholes. The material was mixed in a portable machine and sprayed 1 in. thick into the hole. Then a dome-shaped cover of strips of flexible plastic and wrapping paper was coated with the foam. Stafoam is white, but it can be dyed for camouflage purposes. A nonmilitary use suggested for the foam is for low-cost, underground warehouses.

• • •

If man had wings he could fly, according to D. R. Wilkie, a British physiologist. Dr. Wilkie says that man is physically capable of powering a pair of wings and flying for 15 or 20 minutes. His research also shows that (1) a dog ought to be able to fly even better than a man and (2) we will never see a horse fly.

• • •

Earth-based space study, by means of a "cosmic tower" is proposed by a Soviet scientist. The tower would be some 62 miles high. Atmospheric pressure at this height (one millionth of that at ground level) would permit conducting space experiments and studies. Proposed construction of the tower calls for a funnel-shaped structure of light materials filled with lighter-than-air gas.

Spherical

ROLLER BEARINGS BY LINK-BELT IN CAST STEEL HOUSINGS

THESE ROLLER BEARING PILLOW BLOCKS have spherical roller bearings with internationally standardized boundary dimensions.

The best features of modern bearing design... combined and refined

MAXIMUM SIZE ROLLERS

HIGH, HEAVY INNER RACE FLANGES

CENTRIFUGALLY CAST BRONZE RETAINERS

More than a match for the toughest bearing applications! Link-Belt "MILL BEARINGS" combine industry's finest spherical roller bearings and super-rugged cast steel housings . . . the ideal combination for applications where severe shock loads are encountered.

Two types of shaft mountings facilitate installation . . . adapter mounting for commercial shafting and direct shaft mounting for shafting ground to recommended tolerances. And to assure top performance throughout their long life, these blocks can be furnished with Link-Belt's rugged, multi-labyrinth steel or dacron-contact seals to lock out dirt, lock in lubricant.

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LINK-BELT

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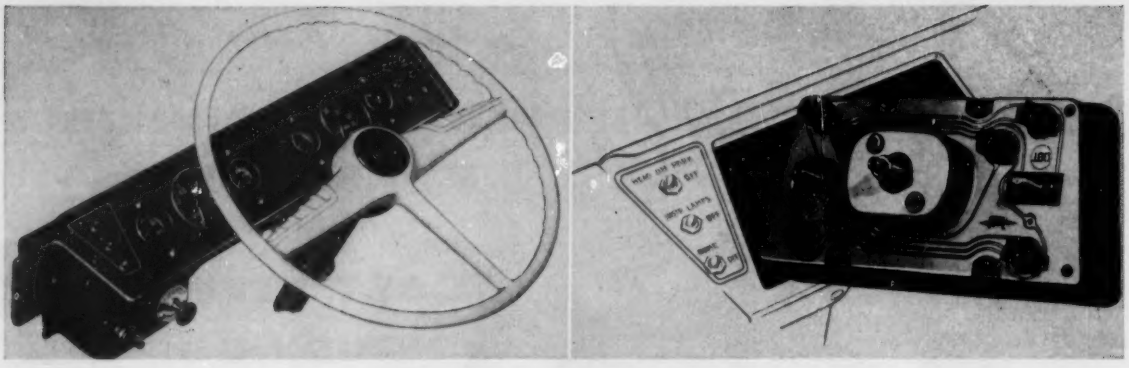

Snap-Out Dash Panels Ease Truck Maintenance

All wiring is printed metallic circuit in new snap-out instrument clusters on GM's 8000 series highway tractors. Individual instruments can also be readily removed for inspection, or the entire subassembly can be completely disconnected from the truck by pulling a single multicontact plug from its socket. The plug is standard with a variable jumper piece across the terminals to provide any electrical circuits required for the particular vehicle.

Manpower in the U. S. Shifts from Brawn to Brains

But Princeton Study Shows Industry Unaware of Evolution

PRINCETON, N. J.—Changes in the industrial personnel picture since World War II show a movement that almost amounts to a stampede into the higher echelons of employment. Number of executives, managerial personnel, engineers, and scientists in American industry is increasing rapidly, while the production work force diminishes.

A study, *Manpower and Innovation in American Industry*, by Samuel E. Hill and Frederick Harbison of Princeton University's Industrial Relations Section, offers an outline of employment changes and an explanation for them. Main reason for an increase in high-talent manpower, according to the authors, is "innovation and hence the pace of progress in American industry." They further believe that future economic growth will be as dependent upon proper development and utilization of brain-type manpower as upon natural resources and investment of capital.

The report shows that professional and related workers increased from less than 1 per cent of total employment in 1910 to more than 7 per cent in 1957. Between 1947 and 1957 employment of production workers increased about 1 per cent, while number of nonproduction workers rose 55 per cent.

Surprisingly, industry seems unaware of the employment evolution. Statistics prepared for the study shocked many of the firms involved. Of the 50 reporting companies, only one had studied past changes in personnel assignments as a guide in estimating future needs.

Of particular interest is the rapidly growing number of engineers and chemists in the labor force. From 1952 to 1957, employment of professional, technical, and related workers increased 45 per cent; it rose 27 per cent in the period from 1955-57.

"Another indication of this trend," says the report, "is the great increase in employment of research engineers and scientists in recent years. In 1941, industry employed 62,000 of these specialists; by 1952 this figure had nearly doubled; and it probably doubled at least once more by 1959, since industrial research expenditures were actually doubled between 1953 and 1957."

Messrs. Hill and Harbison studied employment statistics of 50 companies engaged in a variety of manufacturing and nonmanufacturing enterprises. A typical young industry, an electronics firm, showed the following changes in personnel:

Personnel	Percentages 1950	1955
Executive, administrative and professional	8.8	13.6
Technical and Clerical ..	5.8	16.9
Production	85.4	69.5

Atomic Tie Tester

Nuclear energy is put to work probing for rotten wood in railroad ties. Tie tester, developed by New York Central Research Center, Cleveland, Ohio, and Nuclear Science and Engineering Corp., Pittsburgh, will permit NYC to discontinue mechanical sounding of track ties. The nuclear density tester uses "back scattering," a technique in which gamma rays from a radioactive source are reflected from the interior of sound (dense) wood more readily than from diseased or decayed wood. Hand-held probe contains gamma ray source, detector (sodium diode crystal), and a meter showing degree of back scattering. Key to success of density test is comparatively weak cesium 137 source that does not penetrate ties to give confusing reflections from trackbed.

CASE HISTORIES

New Departure super precision angular contact bearings add new sales appeal to high frequency grinding spindles.

Photo: Courtesy Bryant Chucking Grinder Co., Springfield, Vermont

Ball Bearings Cut Costs $180.00 On 100,000 RPM Grinding Spindle!

CUSTOMER PROBLEM:

Machine tool maker experienced excessive assembly time with integral shaft type ball bearings in the production of 100,000-rpm grinding spindles for precision grinders. The ball bearing, with ground shaft serving as inner race, plus special balls, separator and outer race, required careful parts matching and assembly. Also, shaft and bearing replacement costs, if required, were high.

SOLUTION:

N/D Sales Engineer, in cooperation with the manufacturer, recommended using New Departure production ball bearings fitted directly to the shaft. These super precision, ultra high speed ball bearings eliminated the need for ball track grinding and delicate eccentricity matching at assembly. Using N/D ball bearings and engineering assistance, the manufacturer reduced parts and assembly costs $180 per unit. What's more, in the rare case of spindle damage, shaft assembly replacement costs have now been reduced $175 (over earlier models) . . . shaft assembly or bearings can be replaced separately, thanks to New Departure.

If you have new machine tool designs on the board, or are experiencing questionable costs in production, why not call on New Departure? There's probably a high precision N/D production ball bearing that can save you time or money! For more information, write Department Q-6,

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

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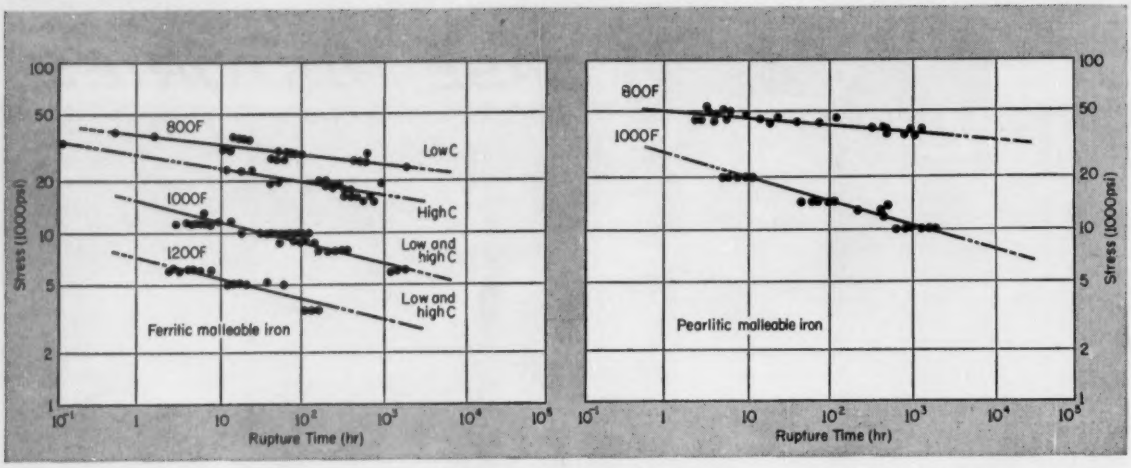


Stress vs. rupture-time plots show gradually falling curves for ferritic malleable iron (left) and pearlitic malleable iron (right). Although the materials were tested to 1200 F, stress curves do not show the characteristic sharp downward break of many materials at high temperature. Samples showed uniform and predictable change within the temperature and time range tested. The lines represent least-squares fit to experimental data shown by dots.

Malleable Iron Proves Out in 800 to 1200-F Range

Promises Low-Cost Material For High-Temperature Parts

CLEVELAND—Malleable cast iron has long been respected as a material combining the best properties of cast iron and steel. Now it's found to have high-temperature properties superior to many other materials. Its strength is almost unchanged up to 700 F. At higher temperatures, strength declines slowly but does not show the abrupt downward break that is characteristic of many commonly used materials.

In a research program carried out at Purdue University under contract from Malleable Founders Society, Cleveland, ferritic and pearlitic malleable cast irons were tested at temperatures that ranged up to 1200 F for periods up to 2300 hrs.

High and low-carbon ferritic malleable and ASTM grade 60003 pearlitic malleable specimens included samples from five different producers of malleable cast iron. Other grades of pearlitic malleable cast iron are being tested to complete the data on high-temperature strength of all malleables. It may now be possible to design malleable-iron valves, fittings, pressure vessels, flanges, and special parts for generating and process industries if specification-writing bodies approve.

Tests showed that stress vs. rupture time of ferritic malleable cast iron was equal or superior to that found for other ferritic materials—especially at 800 F. Strength at the 1000 to 1200 F level is adequate for many uses. There is no evidence of abrupt changes in behavior of materials in tests that lasted over 2000 hours.

Values obtained for pearlitic malleable irons compare favorably with those published for molybdenum-alloyed irons. They are equal to high-carbon materials containing as much as 0.5 per cent molybdenum. In other comparisons, pearlitic malleable iron was superior to other unalloyed cast irons and equal or superior to most alloyed cast irons.

NSPE Elects President, Appoints Two Ambassadors

WASHINGTON—Harold A. Mosher, assistant director of engineering, Eastman Kodak Co., Rochester, N. Y., has been elected president of the National Society of Professional Engineers.

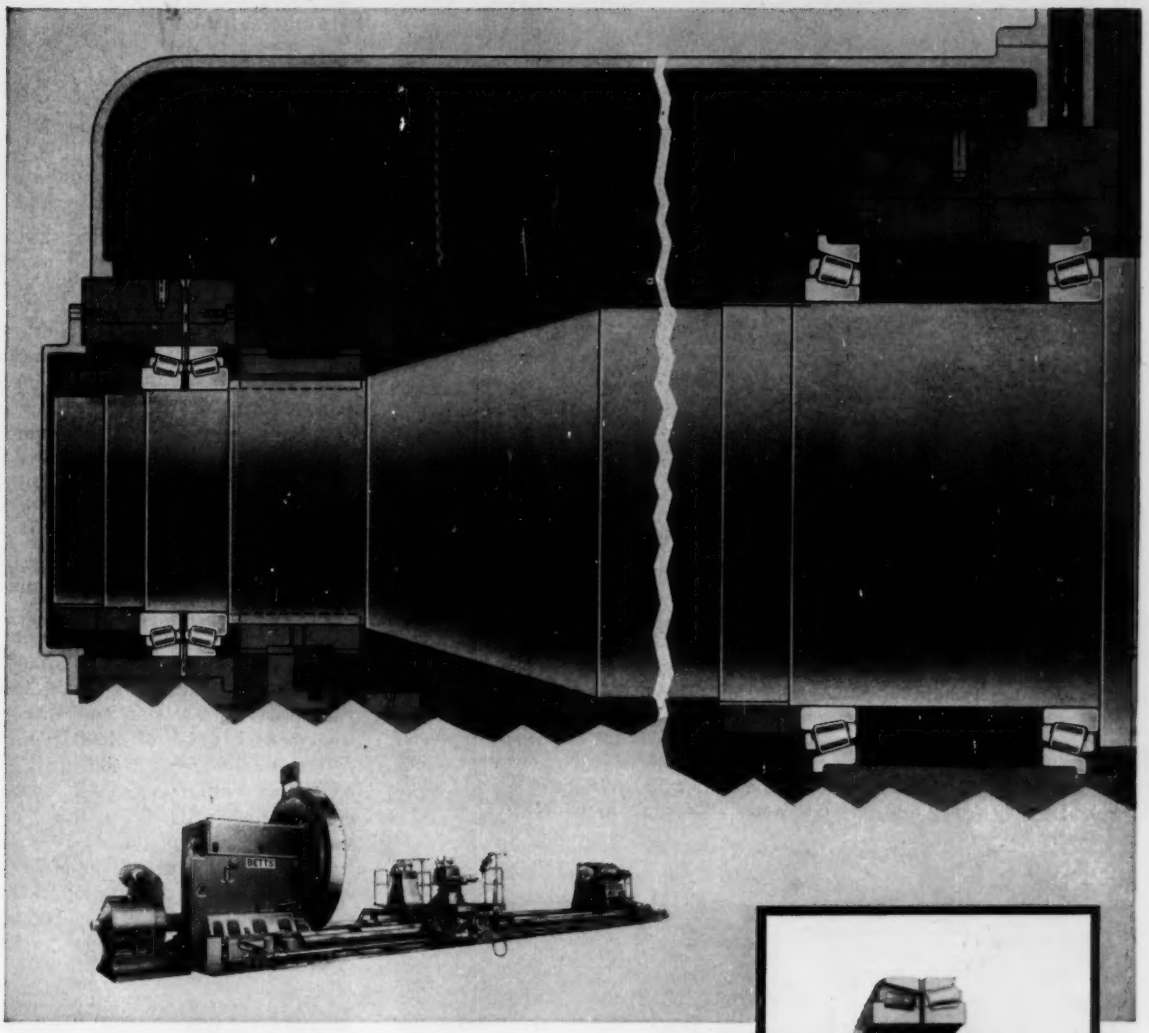
Mr. Mosher is currently serving as a National Society vice president for the Northeastern Region. A graduate of Occidental College at Los Angeles, he has been associated with Bell Telephone Laboratories in New York City, and Consolidated Film Industries in New Jersey.

Mr. Mosher has served as president of the Monroe County Chapter of the New York State Society of Professional Engineers, as a member of the Board of Directors of both the State and National Societies, and as chairman of the NSPE Membership Committee. He is a member of the American Society of Mechanical Engineers and the American Society of Air Conditioning and Ventilating Engineers.

Rodney D. Chipp, director of engineering, ITT Communication Systems Inc., Clifton, N. J., and Dr. Beatrice A. Hicks, president, Newark Controls Co., Bloomfield, N. J., will tour South American countries next March as a part of NSPE's unique Project Ambassador. The project is an effort to forestall the "Ugly American" concept in the minds of those who come into contact with American engineers overseas.

The two "ambassadors" will participate in informal discussions with heads of South American firms, deans of leading South American engineering schools, government officials, and American engineers experienced in the areas they will visit.

Upon their return to the U. S. they will report their observations to NSPE. This report will be the first step in a long-range program to better equip American engineers and technicians to deal with the many social and cultural differences in other parts of the world.

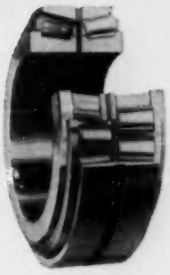


Torrington ultra-precision in large sizes!

The two-row Tapered Roller Bearing shown above is 21.5000″ OD, has a maximum radial and face runout of .0003″, with rotating inner ring and stationary outer ring. At 100 rpm, its radial capacity is 304,000 pounds, its thrust capacity 215,000 pounds.

The single-row Tapered Roller Bearing is 36.000″ OD, with a maximum radial and face runout of .0003″. At 100 rpm, its radial capacity is 319,000 pounds, thrust capacity 272,000 pounds.

Precision in large bearings reflects Torrington's specialized skills and equipment, which enter into the production of every Torrington Bearing, large or small, special or standard. You may not require such precision, but you can be sure your bearing order will receive the care that makes Torrington quality a by-word of industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**



These ultra-precision Tapered Roller Bearings were specially designed and built by Torrington for Consolidated Machine Tool Company's 144″ lathe front and rear-head-block positions.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

TAPERED ROLLER • SPHERICAL ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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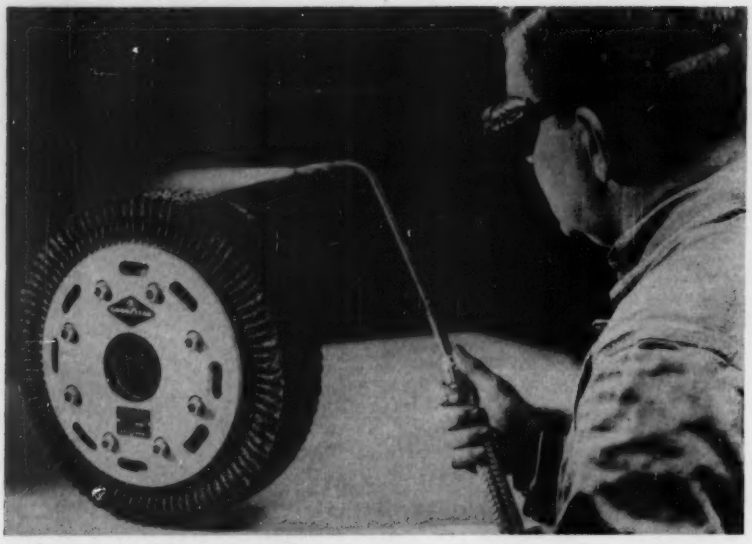
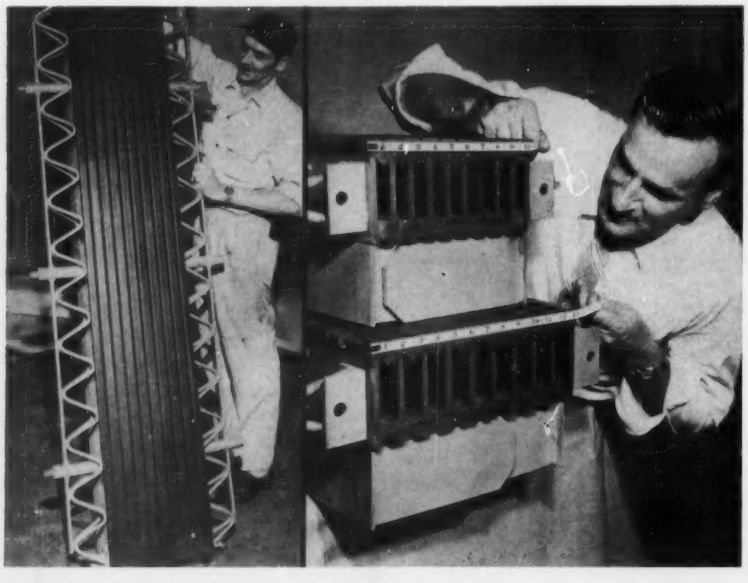


Wire Tire Takes 2000 F

Tires for space craft may resemble wire-wheel attachments for electric drills. Containing no rubber, no fabric, and no air, the unique tires have been developed by Goodyear Tire & Rubber Co., Akron. They're to be used as landing wheels for space vehicles that will pass through the thermal barrier on re-entering the Earth's atmosphere. Tires will withstand temperatures in the 1000 to 2000 F range. Although made of wire, they have load-deflection characteristics similar to those of pneumatic tires. Because they have a higher rolling resistance, they are better able to slow down a fast landing aircraft. Weight of a 14-in. diam tire and wheel is about 40 lb. Test work is scheduled by the NASA.



Rubber Joints Tame Highway Shocks

Accordion-like rubber expansion joints between sections of concrete may make future highways smoother. Developed by B. F. Goodrich Co., Akron, the joints eliminate road shocks motorists encounter wherever pavement blocks have become misaligned. As shown at right, joints can be compressed an equivalent of 3 in. of highway expansion. A road testing program is now underway, and the joint is also being considered for use on airport runways.

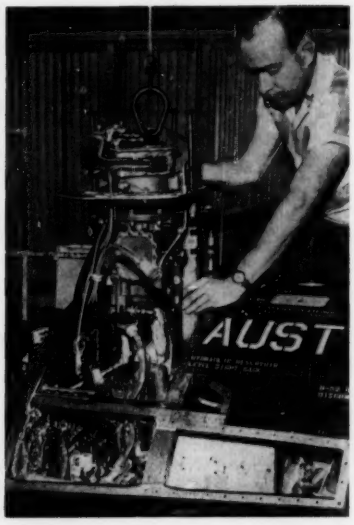
Peroxide-Driven Turbines Control Dead-Stick X-15

Electric, Hydraulic Systems Independent of Rocket Engine

LYNN, MASS.—During last month's glide tests of the X-15 space plane, two small auxiliary power units kept the pilot alive. Without them, he would have had no inertial-guidance equipment, no communications, and no control of speed brakes, landing flaps, and other control surfaces. The APUs supply all electrical and hydraulic power requirements of the plane after the main rocket engine runs out of fuel.

Developed by General Electric's Aircraft Accessory Turbine Dept., the units are driven by hydrogen peroxide in contact with a catalyst. After decomposing into steam and oxygen, the hot, high velocity gases impinge on a single-stage axial-flow turbine. Turbine speed of 51,200 rpm is geared down to a hydraulic-pad speed of 3925 rpm and an alternator-pad speed of 12,000 rpm. Alternator frequency (400 cps) is controlled within one half cycle, even during wide fluctuations in hydraulic load demand.

Each APU produces 4 kva of 400-cps electricity and 16 gpm of 3000-psi hydraulic power. They operate in an ambient temperature range from −40 to 400 F.



Auxiliary power for the X-15 will be provided by two small units like this. When the aircraft's rocket fuel is exhausted, no other power source is available to the pilot. The APUs generate both hydraulic and electric power.

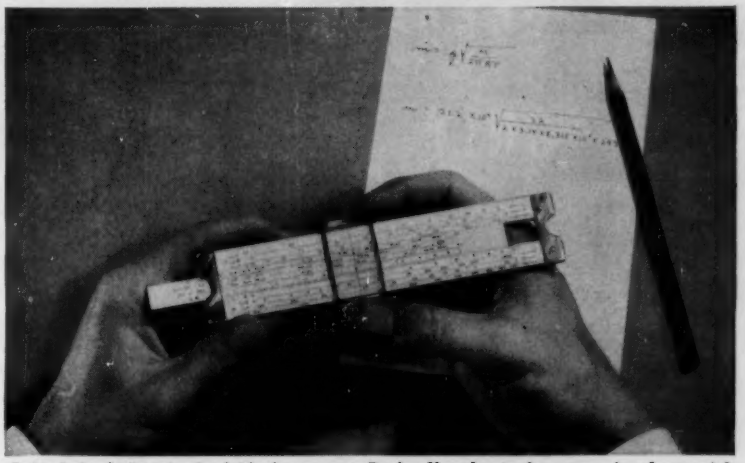
Interoffice Phone System Defers to "Brass" Butt-Ins

No longer must busy people waste time waiting for an interoffice telephone call to go through. A system developed by Tele-Norm Corp., New York, takes over once the call is placed. Offered in the Executive Telephone model, the system has both direct-call pushbuttons and standard automatic dialing features. When the phone is on its cradle, depressing a pushbutton rings the called phone. When that phone is answered, a ready buzzer sounds at the caller's phone. If the called phone is busy, a memory device ties up the circuit and completes the call once the line is free. Cut-in on a busy phone is accomplished by depressing the same pushbutton a second time. Privacy is maintained by an audible signal alerting the conversing parties that a third person has cut in.

Safety on the Yacht

Automatic gasoline-fume detector, for guarding motorboats and yachts against explosions, is made up of a detector unit, left, and an indicator unit. A sensing device in the detector unit emits infrared energy from a platinum-wire catalyst when gas fumes are present in the bilge. A silicon solar cell converts the infrared to an electric signal that actuates a flashing-light alarm. According to the National Safety Council, some 800 boats will be lost this summer from fire and explosion. The new unit is much more reliable than Wheatstone Bridges commonly used for this job, says Raytheon Co., Waltham, Mass., who developed the system. Another attractive feature is its lower price of $99.50

DRAFTING TRENDS



Behind the desk or in the field, the compact Pocket Versalog is the answer for those quick calculations. Weighing only 1½ ounces and having 23 versatile scales, the Pocket Versalog is designed for professional people in all fields of engineering.

Pocket Versalog changes concept of pocket slide rules

Today's engineer must have a slide rule of professional quality . . . with a full range of scales necessary for rapid calculation . . . to solve a variety of problems, accurately and easily.

That's a lot to expect of a standard sized slide rule. It is even more to demand of a pocket rule . . . and, of course, that is the primary reason why 5" slide rules are not used extensively by many engineers, despite the convenience they seem to offer.

A new concept of pocket rules is likely to change this viewpoint, due to the recent introduction of the Pocket Versalog. Here is a slide rule that weighs a mere 1½ ounces, is only 6¾" long, yet contains 23 versatile scales for rapid, surprisingly accurate answers to problems in every field of engineering.

The Pocket Versalog accurately duplicates the famed 10" Post Versalog, with very feature that has made it by far the most universally approved slide rule on engineering campuses today. For example, the same R_1 and R_2 scales permit square root computations with far greater accuracy than A and B scales . . . four log log and four reciprocal log log scales give tremendous versatility . . . and the same new end zone designations of log and log log reciprocal scales speed calculations.

Other features include exclusive color coding of the trigonometric scales which simplifies their use in many ways. In addition, the appearance of the C and D scales on *both* sides of the rule permits easier solutions to many problems.

Built to last

Laminated bamboo is the Pocket Versalog's secret to long life. Only bamboo gives you so many advantages: Protection against warpage, since it resists humidity to a high degree. Natural sealed-in silica, which actually makes the rule function more smoothly as the years go by *without ever requiring lubricants.* A slide that moves perfectly, never too loose nor too tight.

The precision graduations cut into the white celluloid face remain accurate and readily visible during the entire lifetime of the rule, thanks to the extremely accurate engine-dividing of each graduation. Lines are razor sharp . . . they will not smear, fade nor vary.

Convenient to carry in office or on the job, Post's Pocket Versalog is furnished in a handsome leather case with pocket clip. It is lighter, smaller, more compact than any other advanced slide rule on the market.

For more information on the Pocket Versalog, see your local POST *blueprinter or write today to Frederick Post Company, 3652 North Avondale Avenue, Chicago 18, Illinois.*

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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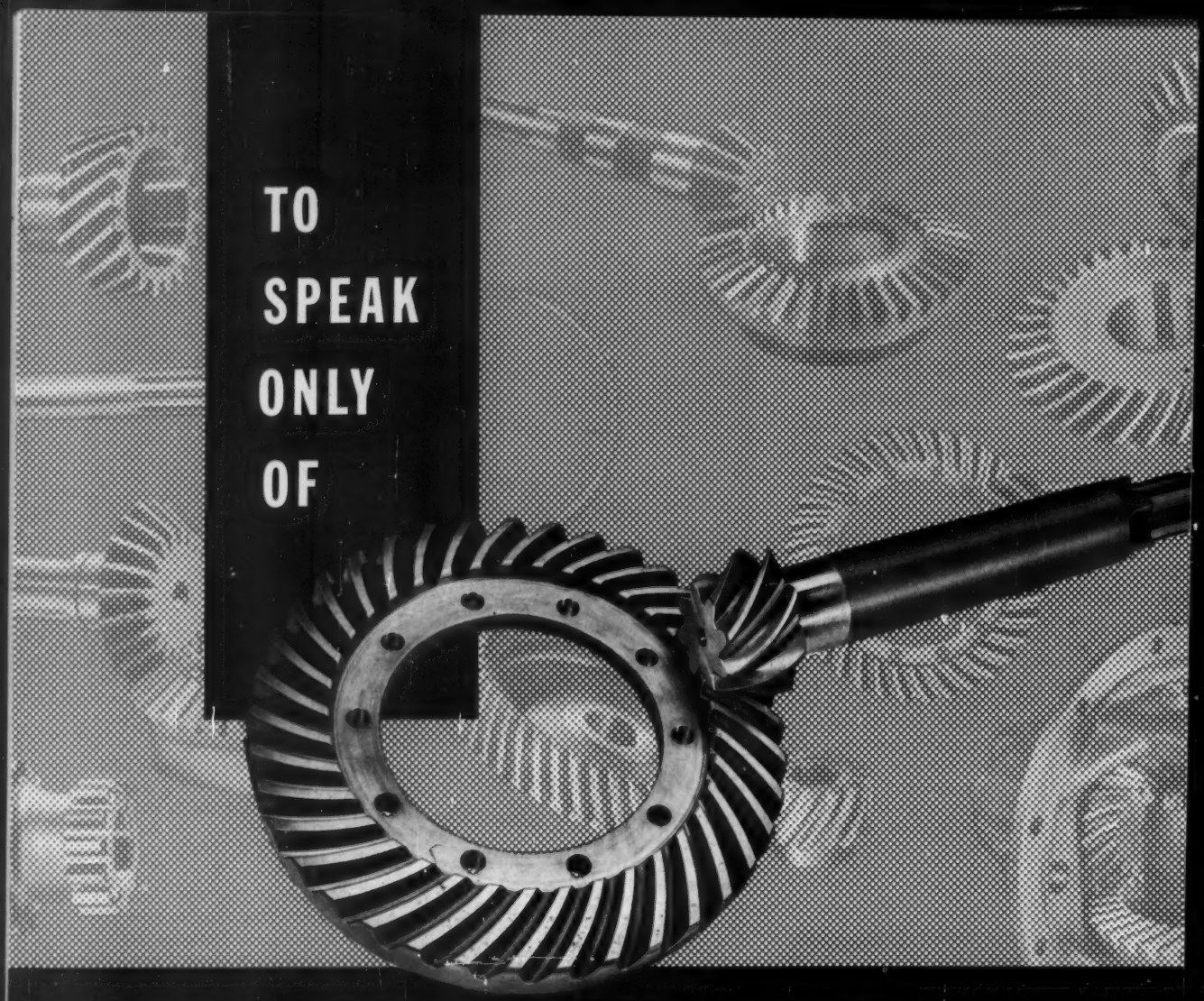

SPIRAL BEVEL GEARS

Spiral bevels comprise just one of the ten gear types in which we specialize, but, speaking of them alone, we have been active in their manufacture since their wide-spread acceptance around 1920. Thus, our experience covers the entire history of this versatile and useful gear type. We were among the first to use lapping on a production basis and to emphasize the importance of lapped and mated gear sets. Automotive Gear was one of the pioneers in developing and promoting the use of special fixtures to eliminate, as much as possible, the chance of human error, and in this way furthered the progress and practicality of spiral bevel installations. Engineering aid in the design of these fixtures for any application is always available to spiral bevel customers . . . as is aid in any area where our specialized gear experience may prove useful. Our gear engineers are available for consultation. Just write!

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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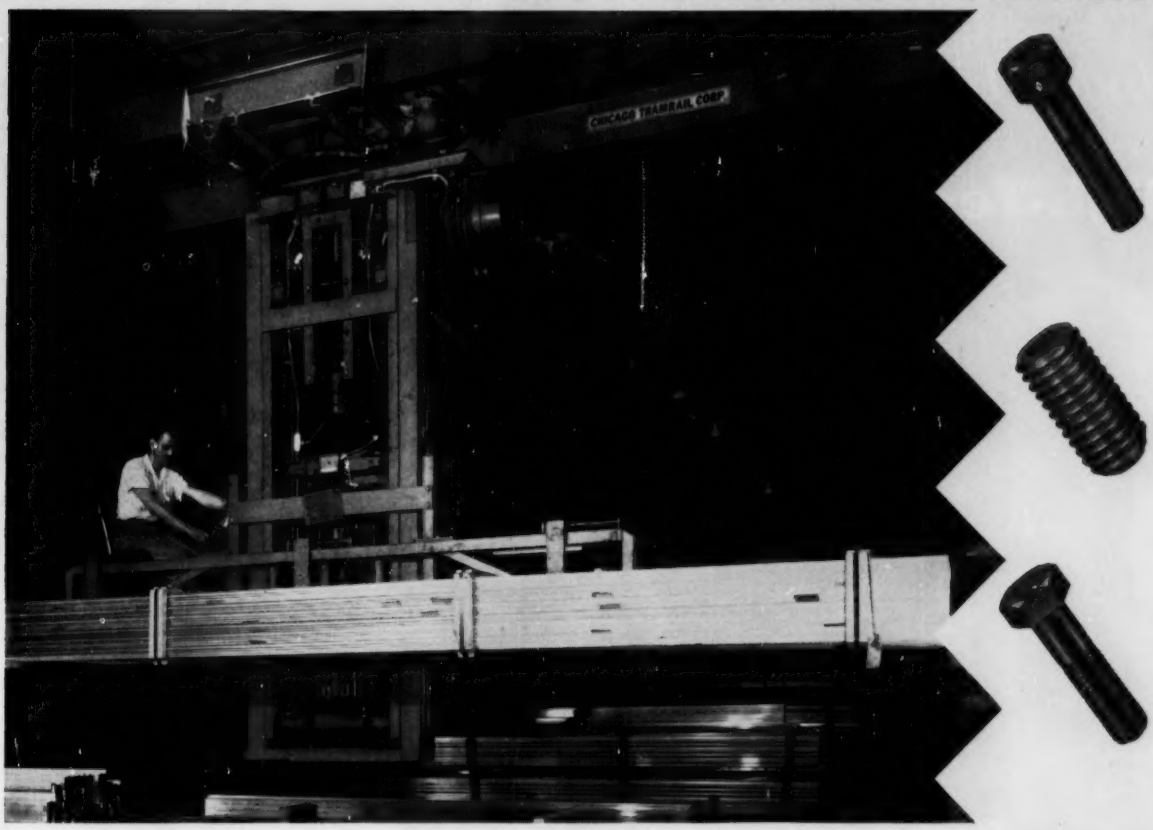
IT PAYS TO STANDARDIZE ON **STANSCREW**



17 different Stanscrew fasteners used in Chicago Tramrail's Trak-Rak

"In constructing our complete line of cranes we make no compromise with the most rigid requirements of safety," says S. W. Fountain, Vice-President, Chicago Tramrail Corporation. "Therefore, reliability is our principle reason for standardizing on quality components such as Stanscrew fasteners."

"But Stanscrew gives us more than fast service and reliable products. Their broad line of over 5,000 fasteners offers a wide selection . . . and their fastener specialists and engineers are always ready to assist our design department in determining the strongest, safest, most economical fastener for every application. For example, in our Trak-Rak stacking crane above, 17 different Stanscrew fasteners are used . . . each selected after careful study for the precise job it has to fill."

Like Chicago Tramrail, many other industrial leaders have learned it pays to capitalize on Stanscrew's backlog of over 80 years of fastener experience. To use this accumulated knowledge in solving your particular fastener problem, just call your Stanscrew distributor. He will quickly arrange for a visit from your Stanscrew fastener specialist.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

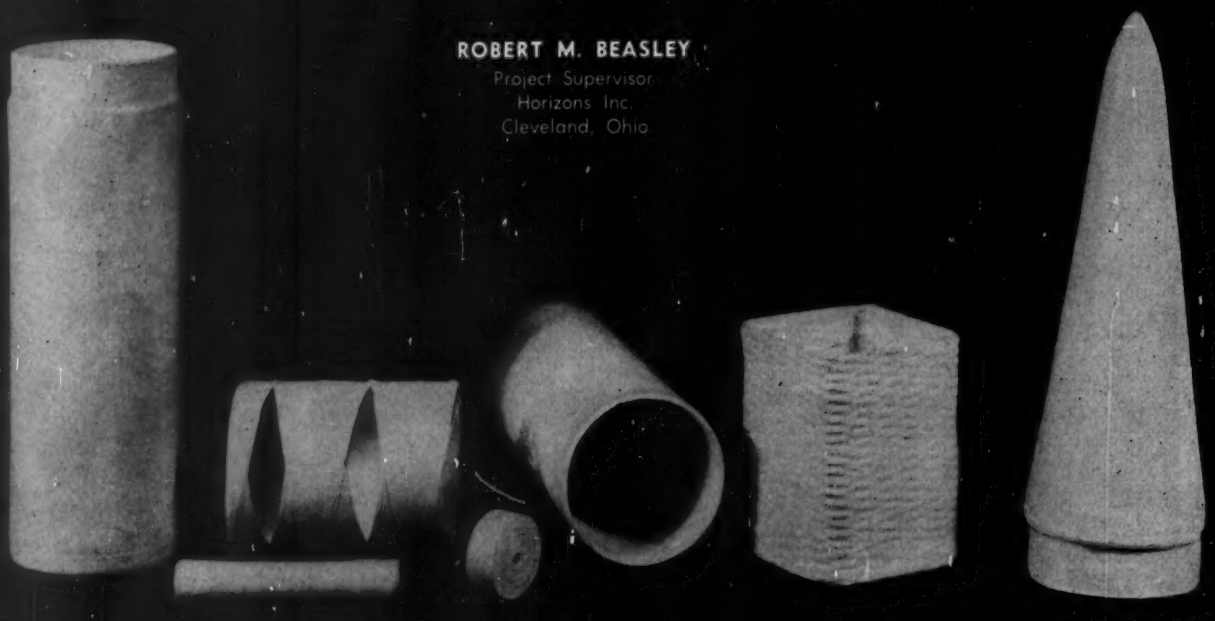
STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 413 on Page 19

Under Intensive Development . . .

High-Temperature Ceramic Laminate

ROBERT M. BEASLEY
Project Supervisor
Horizons Inc.
Cleveland, Ohio



Winding of fibers in the inorganic laminate can be done on mandrels of many different shapes. Designers should avoid re-entrant curves and angles where adequate pressure cannot be maintained between layers. This assures positive imbedding in the matrix.

GLASS-FIBER LAMINATES that withstand temperatures in excess of 1000 F, have strength-to-weight ratios comparable to steel, are unaffected by thermal shock, and display dielectric properties competitive with fused silica are now in an advanced stage of development.

The new laminates, consisting of glass fibers bonded in silica-based matrix materials are being developed by Horizons Inc. for the Electronic Components Laboratory, Radome Branch of Wright Air Development Center.

Aim is to develop a material which can operate in environments up to 1000 F. Glass-fiber laminates with organic plastic binders, widely used for radome construction, are limited to operation at temperatures below 500 F. The new material, though similar, employs the inorganic silica matrix in place of the organic plastic.

Properties of the new material can be controlled. The direction of threads greatly influences properties of the final part and allows for unlimited combinations. Each layer can be a different type of winding. Metal or organic fibers can be wound in with the inorganic fibers.

At first, filament winding was performed by hand or on a machinist's lathe. Both methods employed a straight circumferential wind. Samples made up with this type of wind exhibited strength in one direction only.

To permit winding samples in various directions, a textile yarn-winding machine can be used. With this machine, a seemingly endless variety of winding patterns is possible. This allows control of the internal structure of the article and

What is it?

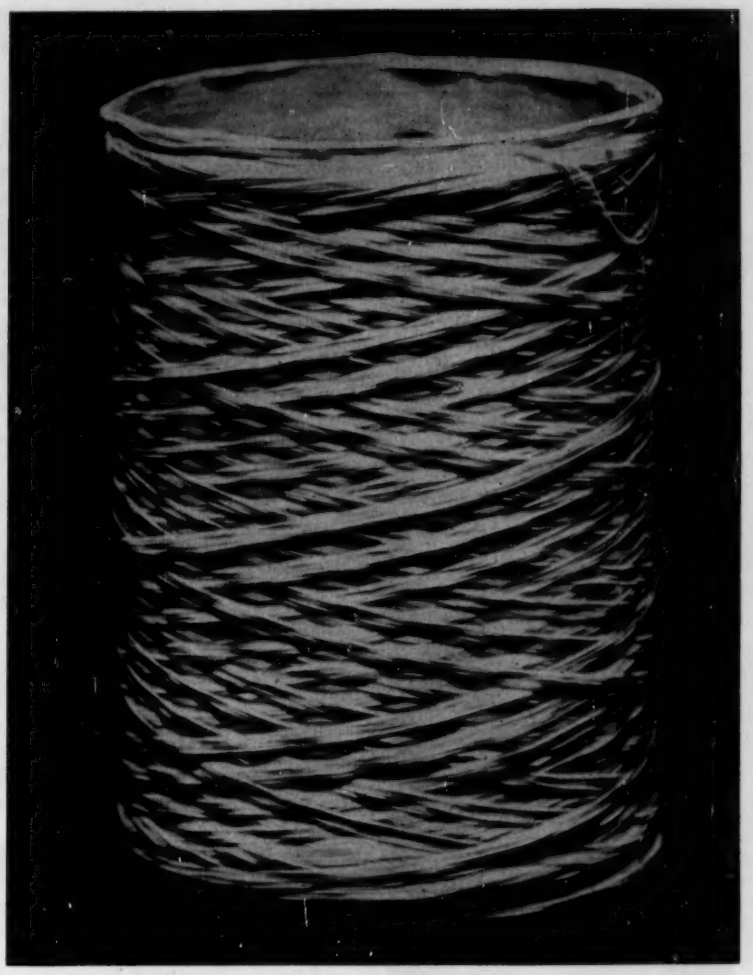
A new inorganic laminate made of glass fibers in a ceramic matrix.

What does it do?

Maintains structural strength above 1000 F; has the weight-strength ratio of steel; shows excellent resistance to thermal shock and a high degree of resilience.

Where's it going?

New ceramic fibers now being produced promise a structural material good for 5000 F.



Open-mesh inorganic basket, made from glass-fiber thread held at points of contact with silica matrix bond, shows one possible winding configuration for the material. Dropped harmlessly from a height of 3 ft onto a concrete floor, it makes a flat sound like a paper carton when it hits.

of the corresponding physical properties like strength, flexibility and failure mechanism.

Potential Applications

First studied for use in radomes, the new material has attractive features for many fields. Its low electrical and thermal conductivity and its textured surface makes it an excellent design choice for items such as coffee pots, handles for tools, household utensiles, and kitchen ware.

On a larger scale, it can be used for missile fuel tanks, for nose cones, for load-bearing structures (especially at elevated operating temperatures), for pipes carrying hot, corrosive liquids, and for filters (in which its porous structure can be used to advantage).

Properties

Besides strength-to-weight ratio comparable to steel, the new inorganic laminate exhibits remarkable resiliency. Figures on modulus of elasticity are not available, but development engineers report that a lead ball dropped on a sheet of the material from a height of 3 ft will rebound 8 in. The same ball dropped on a concrete floor has no appreciable bounce.

Fiber density can be controlled, and strength bears an almost linear relationship to density. One of the most dense samples weighed 2.2 g per cc. Flexural strength was 23,660 psi for a solid cylinder with fibers running circumferentially and longitudinally. Compressive strength for the same cylinder was about 13,360 psi. Tensile strength was not measured, since it was felt

that the ceramic neither added nor detracted from the tensile strength of the glass fiber. It was assumed to be the same as for a similar sample of resin-bound glass fiber.

In flexure tests, samples have been found to fail in compression under the load, while the fibers in tension were unaffected. In a typical test, a cylinder was supported on knife edges and a point load applied midway between supports. Just under the point load, the fibers appeared to buckle or shear, allowing that side to shorten. The side in tension changed dimension very little.

Most organically bonded glass-fiber materials have been tested with fibers in tension only. When stressed in bending and shear, the matrix material comes under test as well as the fiber.

In one method of ceramic build-up, the laminate is repeatedly heated to 1200 F and plunged into an aqueous colloid of ceramic at room temperature. The fact that no specimen has ever broken demonstrates the material's resistance to thermal shock.

The following room-temperature electrical properties were observed on a glazed, silica-bonded, filament-wound sample:

Frequency	Dielectric Constant	Loss Factor
100 kc	3.5	0.0004
1 mc	3.97	0.00034
10 mc	4.15	0.00015

The material is porous in nature. To be waterproof, it must be glazed.

Fabrication

Laminates can be formed by wet-pressing or casting, but it was usually necessary to use pressures great enough to cause the fibers to be sheared or abraded. High strengths are seldom obtained when these forming methods are used.

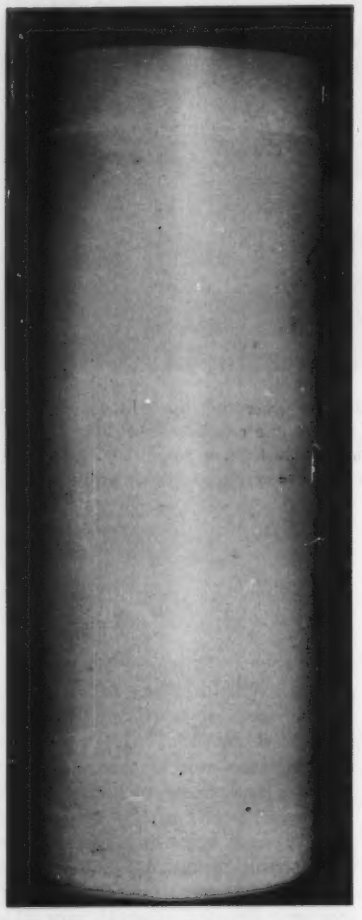
High-strength materials, however, can be formed by "gluing." The gluing technique involves coating the fibers, in the form of fabric or rovings, with the matrix material in a colloidal suspension and joining them together. As expected, best properties are obtained when glued materials were dried under a light load.

Of all forming methods considered, the filament-winding technique achieves by far the best results: Continuous fibers are wound on a mandrel shaped to the desired inside contour of the part. The matrix material is applied to the fibers by brush during the winding operation. The part is then dried and fired.

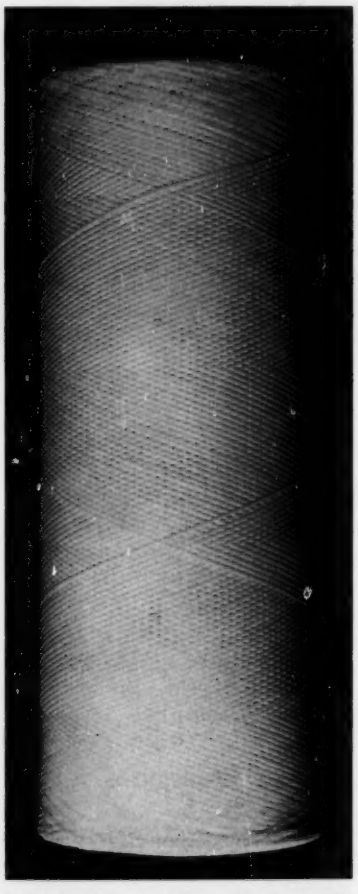
There is little restriction on the size of article which can be formed by this method. There are indications it is easier to precision-form large objects than small ones, since on large samples, the bond can "set-up" during the forming operation. It is possible that when large objects are made, they can be wound, coated, and sintered in one operation. One advantage is that laminates can be formed within dimensional tolerances without the need for subsequent machining or grinding.

Coming—A Higher Ceiling On Temperature

Although matrix materials can be found to withstand 5000 F, the glass fibers are not good above 2000 F as an outside limit. Quartz fibers have limited use up to 3500 F, but present hopes center on a new technique for making fibers from metal oxides. Fibers up to 8 in. long have been made of zirconia, which is useful up to 4500 degrees. Thoria and beryllia fibers may be stable at even higher temperatures. Alumina, silica, and mixed oxides have also been used with some success.



Dense pipeline section represents another form of the material. Mating collar and flange are coated with matrix-forming colloid and reinforced with glass fiber for an almost invisible joint. When dropped on the concrete floor it has a hard ringing sound.



Multidirectional winding clearly visible on this cylinder gives it strength to resist stress in many directions. Filling of matrix material between fibers is often incomplete. Resulting porous material—good for filters—needs a glaze finish to be waterproof.

Available with optional "lock-up" direct drive
Available with optional oil-actuated master clutch
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

New Twin Disc Single-Stage

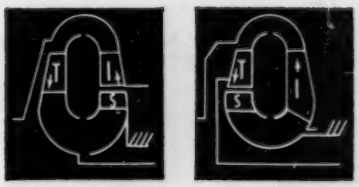
STRIPPED Torque Converters

Efficiency, adaptability, long life — all in one low-cost, compact package — that's the new Twin Disc 1100 and 1300 Series Torque Converter. It's furnished as a "stripped" unit to be designed into any drive line of appropriate capacity. Wherever torque conversion is desired—shovels, cranes, tractors, materials handling equipment — this new unit provides compactness and low cost without sacrificing heavy duty construction.

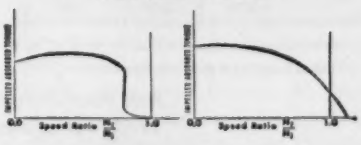
The 1100 Series is rated for engines producing up to 188 hp at 3700 rpm and up to 265 lb.-ft. of torque; the 1300 Series, up to 212 hp at 3200 rpm and up to 330 lb.-ft. Five torque ratings permit close matching of converter to engine for maximum efficiency and fuel economy. Torque converter eliminates engine lugging and stalling . . . cushions out shocks and vibrations . . . automatically matches power to load demands.

Considerable design latitude is provided by two optional circuit designs (see torque absorbtion characteristics at right).

This new "stripped" single-stage converter enables original equipment manufacturers to offer the sales appeal of torque converter drives at the lowest possible cost. See our catalog in Sweet's Product Design File, Folio 6a/TW. Write Rockford office for full details.



Schematic drawings of the two types of single-stage circuits. The Type 1 (outflow) circuit is at left. Type 6 (inflow) is at right.



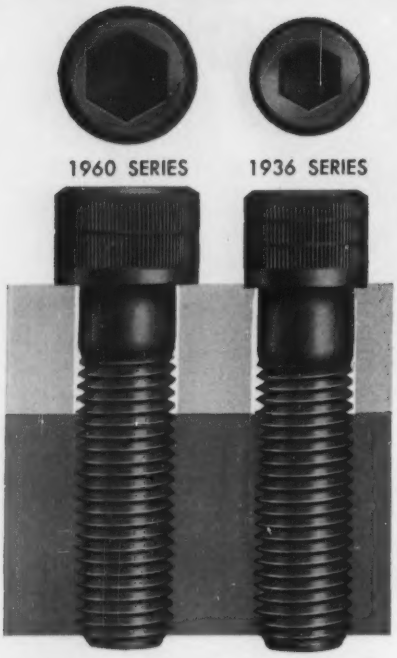
A comparison of the torque characteristics of the Type 1 circuit (left) and the Type 6 circuit. The Type 1 circuit unloads the engine quite abruptly at a speed ratio of about .825. The Type 6 design allows a no-load speed ratio of 1.15:1.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS

Circle 426 on Page 19

Allen's *New '60 Series* Socket Head Cap Screws



give up to 2⅓ times more load carrying capacity ...without indentation!

In Allen's new '60 Series, head diameter of sizes from ¼" up is now uniformly one and one-half times the body diameter. In many sizes (where this ratio was not called for by 1936 Series specifications) this will provide *more* under-the-head bearing surface, and a proportionate *increase* in clamping force. Loads are more evenly distributed, and the greater bearing area in many cases eliminates need for washers.

Socket sizes have been increased in many cases—greater wrenching area permits higher tightening torque—which resists fatigue failure, and lengthens the life of the threaded joint.

- A new 2-band knurl will identify all ALLEN Cap Screws (except Stainless Steel) that conform to the new '60 Series specifications. New labels on boxes will also identify these.
- The 1936 Series of Allen Cap Screws will continue to be available.

COMPARISON OF ALLEN 1960 SERIES AND 1936 SERIES SOCKET HEAD CAP SCREWS

SCREW SIZE	HEAD DIAMETER Minimum (Inches)		BEARING SURFACE Minimum (square inches)		PERCENT OF INCREASE IN BEARING SURFACE[1]	TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)		TORQUE INDUCED TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)	
	1960 Series	1936 Series	1960 Series	1936 Series		1960 Series	1936 Series	1960 Series	1936 Series
¼	.365	.367	.044	.044	—	4,750	4,750	2,780	2,780
5/16	.457	.429	.070	.052	33	7,440	5,600	4,380	3,300
3/8	.550	.553	.111	.111	—	12,100	12,100	7,000	7,000
7/16	.642	.615	.140	.103	36	15,000	11,000	8,850	6,450
½	.735	.739	.183	.183	—	19,500	19,500	11,500	11,500
5/8	.921	.863	.293	.216	35	31,000	23,200	18,500	13,600
¾	1.107	.987	.424	.224	89	45,000	24,000	26,700	14,100
7/8	1.293	1.111	.585	.253	131	62,500	27,000	36,800	15,900
1	1.479	1.297	.768	.405	89	82,000	43,500	48,500	25,500

[1]Head tolerance revisions on Sizes #0 thru #10, ¼, 5/16, and ½ diameter have no significant effect on bearing surface or holding power of screws.

[2]Values based on .00025 inch indentation.

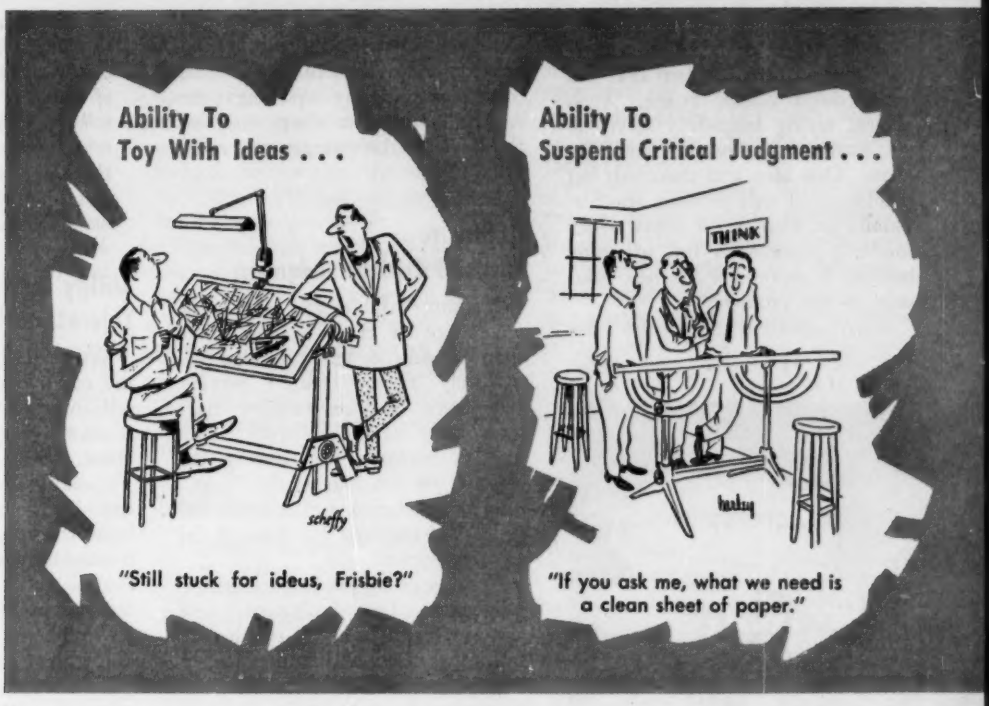
Ask your Industrial Distributor about ALLEN '60 Series Cap Screws. Write for samples and complete specifications. Ask for Bulletin G-25.

ALLEN MANUFACTURING COMPANY
Hartford 1, Connecticut, U.S.A.

Stocked and sold by leading industrial distributors everywhere

ALLEN HEX-SOCKET SCREWS HEAD

Circle 414 on Page 19


Ability To
Toy With Ideas . . .
scheffy
"Still stuck for ideas, Frisbie?"
Ability To
Suspend Critical Judgment . . .
THINK
"If you ask me, what we need is
a clean sheet of paper."

30 Attributes of

The Creative Engineer

Part 3—Mechanics of Creativity

EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea Inc.
New York

WHAT CHARACTERISTICS provide the tip-off to the creative engineer? Certain personality traits and intellectual abilities—rounded up in Parts 1 and 2 of this series—are essential. But all engineers who rate high on these attributes are not necessarily creative. Why? Often it's a matter of poor technique—the absence of "know-how" in applying the mechanics of creativity. Eight such techniques for creativity uncovered in a survey of experts are reported in this concluding article.

Ability to Toy with Ideas . . .

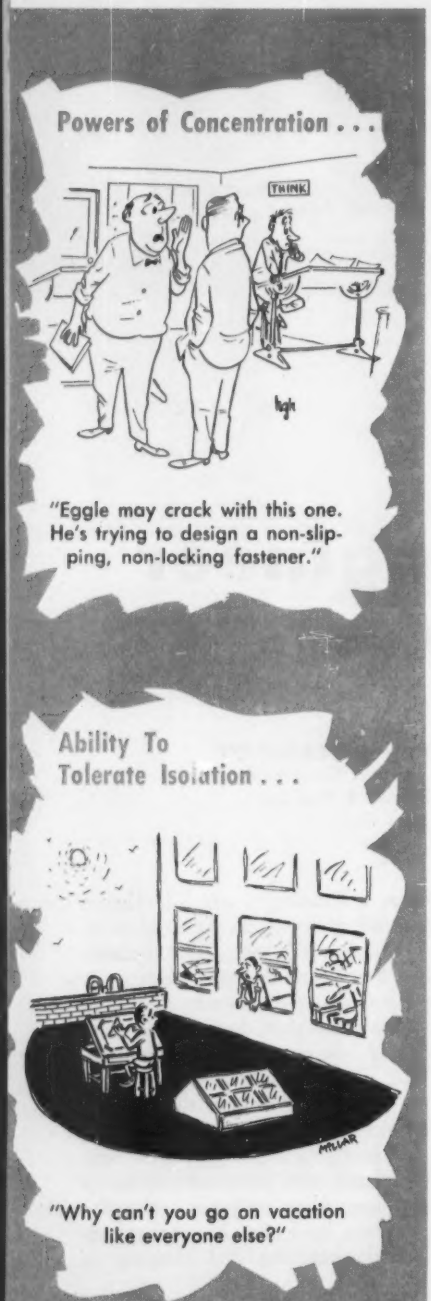
The creative engineer is inquisitive and curious, self-generative and self-resourceful. He is constantly seeking new ideas, constantly exploring, experimenting with and testing those he has.

There may appear to be a light side to the technical person's serious exploration and experimentation. To the outsider, he seems to lose himself in an irresponsible playing with ideas, forms, materials, relationships, and concepts, which he shapes into all kinds of incongruous combinations. He does this because he has learned how apparently purposeless exercise strengthens and, at the same time, loosens the muscles of originality and imagination. This exercise enables him to come up with more unique solutions to problems.

Improvising and toying with concepts can also serve very concrete and immediate purposes. Creative engineers have often found that haphazard sketching and shaping of

ideas help them chance upon a creative solution to a problem that has defied direct frontal attack. Such playful toying frequently serves to get them into a proper mood for ideas. One idea will then pull out another, and this in turn another. Finally an idea is hit upon which suddenly commands full attention because it represents the best solution to the problem.

Many creative engineers have learned from experience that quasi-serious exercises relax the critical and conservative orientation of their consciousness. By putting the watchful censor to sleep, they set the stage for the emergence of novel solutions.


Powers of Concentration . . .
THINK
"Eggie may crack with this one. He's trying to design a non-slipping, non-locking fastener."
Ability To Tolerate Isolation . . .
"Why can't you go on vacation like everyone else?"

Ability to Suspend Critical Judgment . . .

Nothing inhibits and stifles the emergence of creative ideas more than critical judgement applied prematurely in the creative process. Judgement and evaluation have their place at the conclusion, not at the beginning or during the creative process. During the "heat," total self-abandon and self-submergence are required for flow of the creative current.

Creative engineers suspend critical judgement. They don't need "rapid closures," and hold off conclusions until the pieces fall into place.

Importance of this attribute was recognized long ago by Dr. Sigmund Freud. He wrote: "Regarded in isolation, an idea may be quite insignificant, and venturesome in the extreme, but it may acquire importance from an idea which follows it; perhaps in a certain collocation with other ideas, which may seem equally absurd, it may be capable of furnishing a very serviceable link."

Powers of Concentration . . .

The creative process requires a high degree of concentration, one in which the creative person becomes oblivious to everything else. He has to maintain an uninterrupted rapport with the "proposals" that emerge from his unconscious. As Richard Wilbur has pointed out, "he shapes them into something that makes daylight sense." This requires great self-discipline. Professor Richard Guggenheimer explains it this way:

- *A great disciplinary effort is required for most productive minds before they reach a stage where they are able swiftly to launch themselves into completely spontaneous absorption in the creative business at hand. A thousand and one diverting thoughts must be suppressed; the mind must brush aside myriad temptations to amble here and there along the enticing byways of casual thinking. It must become totally involved in the mounting wave of its deep intent. The principal labor is getting the wave started; most of us splash about in our thinking and mistake the ripples of our noisy commotion for real movement.*

Ability to Tolerate Isolation . . .

When ready to think creatively, the creative engineer isolates himself from his environment. When in an actively receptive but leisurely mood, he entertains the problem. To enable the emergence of creative ideas, he must free himself from the usual environmental distractions and administrative or routine duties. Real creative thinking cannot be done in a distracting environment or during the rush of regular duties.

To his ability to stand temporary physical withdrawal, the creative engineer adds tolerance of psychological isolation. He knows that enhancement of his capacity to invent requires "psychological distance" from his associates and the working environment. He must purge his problem from such considerations as scheduling, costs, supervisor's pet ideas, and the like. He learns from experience that such considerations block the emergence of novel ideas by inducing anxiety and guilt feelings because he is not doing what is expected of him.

One warning, however, is in order. Prolonged periods of physical isolation and psychological standing apart tend, as a rule, to deflate and devitalize, rather than to enhance the capacity to create. Imaginations shrink and shrivel. They have to be constantly nourished and fed by active immersion, commerce and participation with others.

Persistence . . .

An almost heroic capacity for taking pains, an obstinate persistence in the face of difficulties and frustrations, and a vast amount of sheer arduous work distinguish the true creative engineer from his less creative colleagues. The importance of persistence has been underlined by several authorities in the field:

- *When he (the creative engi-*

neer) meets with the difficulties that inevitably arise in the course of his work, he must persist in struggling with them until he has overcome them, no matter how long it may take. For this he requires both energy great enough to sustain him in the most arduous kind of mental labor and also complete confidence in his ability to attain final sucess."—WILLIAM H. EASTON

• *Nature yields her secrets with reluctance.* — DR. ALFRED N. GOLDSMITH

• *Solutions to many problems remain undiscovered because inventors ran out of creative energy just when they were on the brink. . . . It is just when we strike these seemingly impenetrable bastions that we tend toward despair . . . and it is just then that we are on the verge of solution.*—WILLIAM J. J. GORDON, Arthur D. Little Inc.

It is interesting to note that the quality of persistence is one of the salient characteristics in the biographies of most creative individuals. It is also the one they emphasize most when counseling others with creative aspirations.

This factor of persistence emerged also as a prime requisite for creativity in a study Joseph Rossman conducted some years ago. He sent a questionnaire to hundreds of inventors, directors of research and patent attorneys, asking them to rate the requirements or traits necessary for creative achievement. Persistence and never-ending application, together with originality, analytic ability, and imagination appeared most frequently as the primary prerequisites in the responses of the three groups.

The capacity for painstaking work constitutes both the prologue and the epilogue to the moment of illumination or creative insight. Labor before the idea's advent is an extensive collection, rehearsal, and survey. After the idea's occurrence, the labor becomes intensive industry, concentrated on the goal. This phase in the creative process also requires great persistence and hard work.

As Professor John E. Arnold has stated: "There is a great deal of work associated with the polishing and repolishing of an idea before it becomes an acceptable, tangible result. I am very disturbed and upset by the great number of people who are writing and speaking today on this general subject, and who seem to believe that the idea is, in itself, the beginning and the end of the creative process."

The creative person is able to maintain his morale and efficiency despite difficulties. Although he has experienced failure, he has not been crushed. He has power of endurance. He can work under pressure over extended periods of time and at the same time retain perspective and clear vision.

Incubation . . .

During the creative process there comes a time when thinking becomes ponderous and heavy, or dull and clogged. When this occurs the engineer finds errors start to pile up and no significant new insights occur. This is the time when he ceases work on the problem and turns to something entirely different.

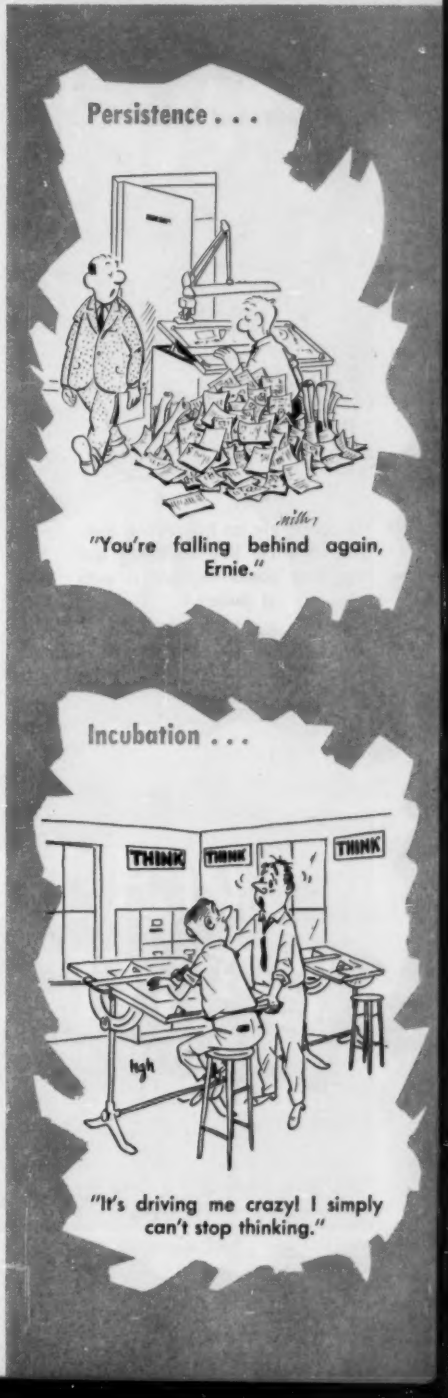
• *Although he has confidence in his ability, the creative person also has an attitude of respect for the problem and admits the limits of his conscious power in forcing the problem to solution. At some point, called "incubation" by many who have reported the process, he treats the problem "as if it had a life of its own," which will, in its time and in its relation to his subliminal or autonomous thought processes, come to solution. He will consciously work on the problem, but there comes a point when he will "sleep on it."*—DR. JOHN M. SCHLIEN, University of Chicago

The creative engineer also likes to contemplate, reflect, meditate, or just engage in the "chewing of the mental cud." It is frequently during those periods that he gets some of his best ideas.

Discernment and Selectivity . . .

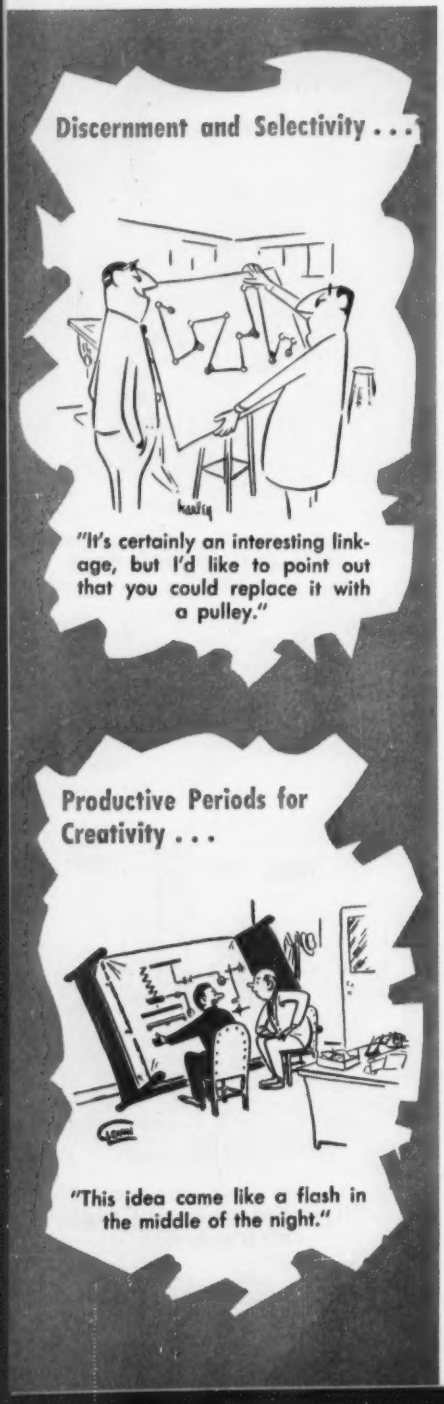
The strong emphasis on the attribute of "fluency" has overshadowed the importance of another frequently overlooked attribute in the discussions about the creative personality. This is the ability to discern the fundamentals in a problem, an ability to be selectively attuned to it. This factor of discernment, is, in some ways, diametrically opposed to fluency, but is as crucial and vital an attribute for creativity.

Creative engineers differ from the less creative or the noncreative mainly in the quality they evidence in their selection of elements when confronting a problem. They are able to choose the more funda-



mental aspects of the problem. In creative problem-solving, it is not necessarily the person who is highly fluent about the problem, nor the one who reaches the highest degree of abstraction in analysis who shows the highest degree of creativity. Most frequently it is the person, whether fluent or not, who has grasped the heart of the matter. This person, thinking most to the point and understanding the central principle or the core of the problem, evidences the highest degree of creativity. In creative thinking quality counts more than quantity of ideas produced. Ideas can add up to nothing if the central point is missed.

Dr. Schlien is one authority who has recognized the importance of this factor. He states: "The creative person exercises choice, taste, discernment. He is not sorting through possibilities with the vague hope that something will turn up. He operates on a hunch, or a hypothesis, which gives him a determined aim. The unique result he achieves might have been reached mechanically by combining all known elements in all possible ways, but that would produce an almost infinite number of useless combinations. The creative act, however, is efficient because it is not mechanical. Even if he stumbles on a lucky accidental finding, the creative searcher will recognize that it fits the direction of his aim."


Discernment and Selectivity . . .
"It's certainly an interesting linkage, but I'd like to point out that you could replace it with a pulley."
Productive Periods for Creativity . . .
"This idea came like a flash in the middle of the night."

Productive Periods for Creativity . . .

The creative engineer develops a "retrospective awareness" of the periods when he solved his problems creatively. He takes note of the methods that were successful and those that failed. He trys to learn "why" by retracing the routes he followed and those he avoided as far as possible. He knows, in short, that self-knowledge in the area of creativity will facilitate idea-production.

The creative engineer schedules creative thinking periods for those times when he is at his best for producing ideas. He is aware of his personal rhythms and peaks and valleys of output. By keeping a record of those periods in which he is most creative, he can establish a pattern and plan ahead, reserving peak periods for concentration, contemplation and uninhibited thinking, and less productive time for investigation and evaluation. Even if he has not established a time-sheet of productive periods, he at least has developed a sensitivity to those moods that promise really creative returns from his efforts, and he knows when they are approaching.

Metals Matters

An electron beam . . .
welds reactive metals in a high vacuum. It's done in a welding chamber developed by National Research Corp., Boston, Mass. NRC electron gun in the top of the unit is protected from gaseous discharges as it directs a beam of high-energy electrons at the work. A sound, ductile joint can be made by a welder of average ability at ½ in. per sec.

Titanium alloy tubing . . .
approaches the strength of stainless steel, but is ductile enough to be cold-drawn or flared. Strength of annealed titanium is doubled by adding small amounts of aluminum and vanadium. Superior Tube Co., Norristown, Pa., guarantees a minimum yield strength of 75,000 psi for 3Al-2.5V in the annealed condition, over 100,000 psi after proper heat treatment, and 35 per cent minimum flare in the annealed condition. Fatigue strength is high; an unnotched annealed bar withstood 10^8 cycles at 45,000 psi.

Extruded copper billets . . .
are products of a new mass-production technique at Halstead Metal Products Inc., Zelienople, Pa. Liquid metal from an electric-arc furnace is fed to two semicontinuous casting machines mounted in tandem. Cast 12-ft "logs" are cut into billets with power saws. Billet diameter is 7 in.; length can be varied to suit needs of a particular product.

High-temperature conductor . . .
of copper alloy containing a small amount of zirconium, retains its properties at elevated temperature. A sample with 0.1 per cent zirconium had 40,000 psi yield strength at 500 C. Conductivity was over 90 per cent. American Metal Climax Inc., New York, calls the new alloy *Amzirc*.

Protective coatings . . .
of chromium, molybdenum, or tungsten, can be applied to base metals by an improved vapor-phase technique reported by Alloyd Research Corp., Watertown, Mass. Chromium coating 0.005-in. thick on steel showed no cracking, spalling, or flaking after extensive deformation. The same thickness gave complete protection to a copper base when immersed in a 20 per cent nitric acid solution for 64 hr. In contrast to electroplating, this process does not risk hydrogen embrittlement of the substrate.

Here's the inside story of industry's

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A tremendous operating life has been built into these new A-B high voltage, air break starters by using the same simple solenoid design—with only ONE moving part—that has proved good for millions of trouble free operations in Allen-Bradley low voltage starters. A-B high voltage starters are made for all types of service and for all types of motors up to 1500 hp, 2300 v; 2500 hp, 4600 v. Send for Publication 6080, today.

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New blowout design. Novel arc chutes are molded from an arc resistant material.

Double Break Contacts
Silver alloy contacts never need maintenance. Vertical motion assures uniform contact pressures.

Only One Moving Part
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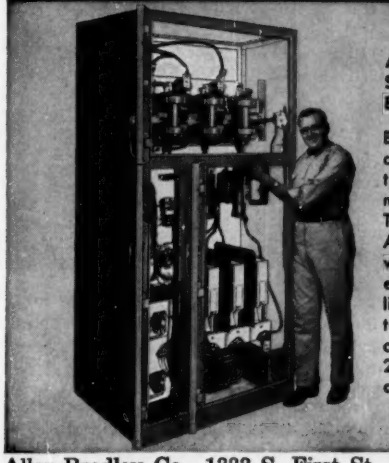

A-B High Voltage Starter with Air Break Contactor

Bulletin 1159 high voltage air break, across-the-line induction motor starter in NEMA Type 1 enclosure. All Allen-Bradley high voltage starters are equipped with current limiting fuses with interrupting capacities of 150,000 kva at 2300 v; 250,000 kva at 4600 v.

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Capsule Report: Safety and Comfort

KEEPING Project Mercury's man-in-orbit reasonably comfortable in space and bringing him down safely through the re-entry heat thicket are tough design problems well on their way to solution. Two subcontractors to McDonnell Aircraft—holder of NASA's Mercury contract—have released details on the capsule's automatic environmental control system and its beryllium heat sink. Here are up-to-date progress reports from AiResearch Div., Garrett Corp., Los Angeles, and Brush Beryllium Co., Cleveland.

Atmosphere in Orbit

Environmental control system in the Mercury capsule will be under the "pilot's" seat. AiResearch, developer of the system, designed it for automatic operation, although it can be hand-operated in an emergency. Two 28-hr supplies of oxygen are to be bottled under 7500 psi. The second is a reserve in case of failure or exhaustion of the first.

Just before launching, a ground crew member opens a valve releasing pure oxygen into the capsule and into the space-traveler's flight suit. After launching, purge of the capsule begins so that at 25,000 ft the capsule contains essentially pure oxygen at 5 psia (about equal to the pressure near the top of Mt. Everest). This is where the purge system shuts off. Pressure in the capsule and suit is kept at 5 psia.

During descent, after the vehicle returns to 20,000 ft, capsule atmosphere will be cooled and refreshed by air entering two snorkels opened by a barometric control. These automatically close if the capsule lands in water. With the capsule floating properly, they reopen to admit fresh air.

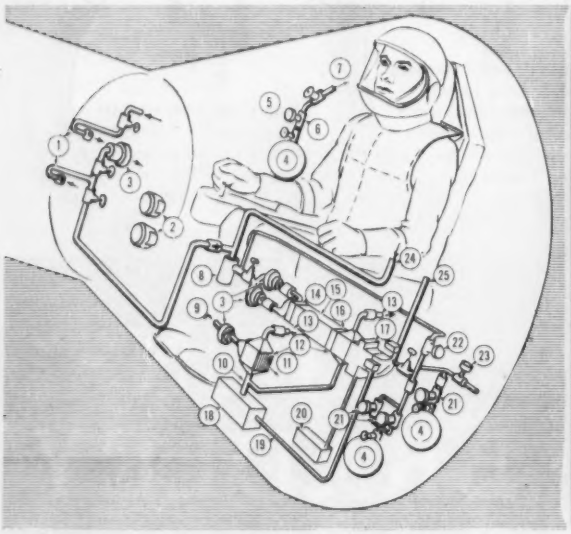
The environmental control system will operate in temperature conditions from −20 to +200 F. It is not affected by "zero-g." In the event of decompression of the capsule, the suit remains pressurized and continues to supply the flier's minimum requirements.

Saucer Absorbs Re-Entry Heat

If a man-carrying capsule were to return to earth by the most drastic trajectory possible—similar to the path of a meteor—it would have to get rid of almost 10,000 Btu per lb of vehicle very quickly or become a shooting star. At high temperatures, sublimation of beryllia occurs, carrying away more than 10,000 Btu per lb of material. This makes beryllium very attractive as a heat-consuming material. Even under less drastic conditions, beryllium's high specific heat (0.5 Btu/lb/F) makes it an effective heat sink.

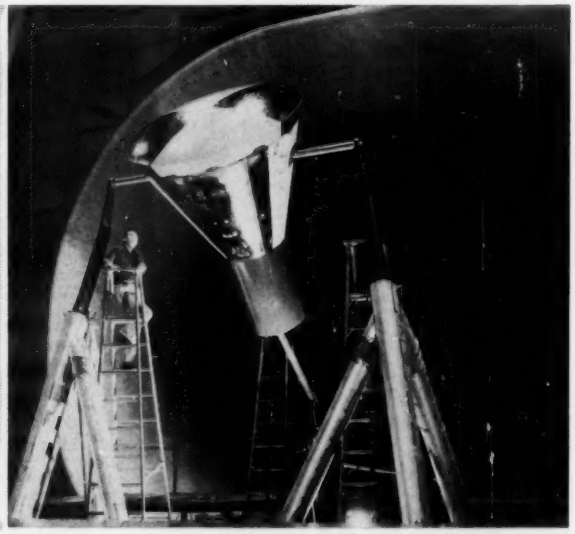
Besides high specific heat, beryllium has excellent thermal conductivity—similar to sodium, molybdenum, and magnesium. What's more, although almost transparent to x-rays, it reflects 55 per cent of the white light directed toward it—an important factor in space travel.

A 6 ft dish of beryllium will be used as the floor of the cone-shaped capsule. Brush Beryllium, Cleveland, will produce a sintered beryllium billet having the largest diameter (64 in.) ever produced. From this billet, Alcoa will forge a 6-ft diam blank to be machined into the dish-shaped heat sink. Forging is to be done under the Air Force Heavy Press Program on a 50,000-ton press located at Alcoa's Cleveland plant. A steel envelope encasing the billet will protect it from oxidation while it is forged at temperatures above 1500 F.



SYSTEM DETAILS

1. Snorkels
2. Pressure relief valve
3. Fans
4. Oxygen bottles
5. Purge system
6. Pressure reducer
7. To cabin
8. Debris trap
9. From cabin
10. Water lines
11. To cabin
12. Heat exchangers
13. Overboard
14. Odor absorber
15. Carbon-dioxide absorber
16. Filter
17. Water absorber
18. Cooling tank
19. Tank pressure line
20. Water tank
21. Pressure reducers
22. Demand regulator
23. Pressure regulator
24. From suit
25. To suit



Capsule atmosphere of pure oxygen is maintained at 5 psia by environmental control system shown at left. Suit pressure is independently maintained to protect the man if cabin pressure fails. System can be hand-operated.

Full-scale model of man-carrying capsule, right, undergoes aerodynamic tests in NASA wind tunnel to prove stability in flight. Base of the cone is the dish-shaped beryllium heat sink which will be at the back of the space man.

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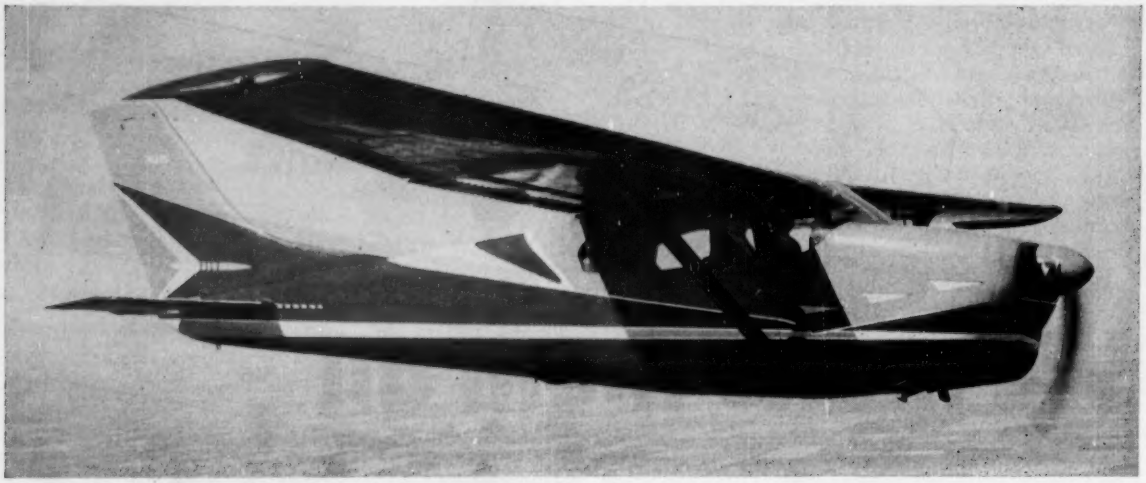


Cessna 210 Will Have Retractable Gear

First high-wing, single-engine plane with retractable gear will be offered by Cessna Aircraft Co., Wichita, Kans., this fall when their model 210 is put on the market. Main landing gear retracts beneath the baggage compartment, nosewheel retracts into a fairing below the propeller spinner. Drooping, low drag wing tips and swept vertical tail give the craft exceptional stability. Powered by a 260-hp fuel-injected engine, it cruises at about 190 mph.

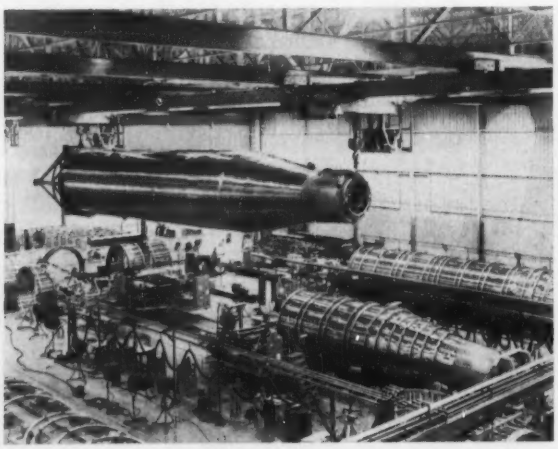
Atlas Missile Details Released by Air Force

Thin-Skinned Fuel Tanks Depend on Internal Pressure

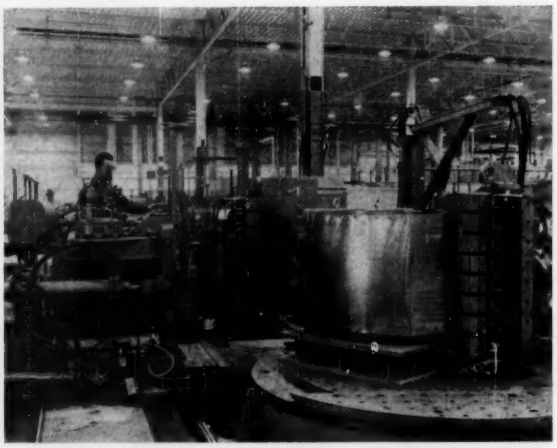
SAN DIEGO, CALIF.—Fuel tanks for the Atlas missile, although 60 ft long and 10 ft in diam, are built of stainless steel not quite as thick as a dime. Such design is possible because the missile's skin is kept under internal pressure to keep it from losing its shape.

Eliminating stiffening framework gave Atlas a very favorable mass ratio, the ratio of the rocket's weight at launching to its weight when all propellant has been burned. The higher this ratio, the greater the flight range of the missile.

Atlas construction details, recently released by the Air Force, explain how such a tank works. Originator of the pressurized-tank idea is K. J. Bossart, technical director of Convair—Astronautics. Modeled after the aircraft industry's integral wing tank principle, in which the



This 60 ft tank for an Atlas ICBM is being moved from the tank manufacturing area. All supports have been removed from the thin-skinned tank and it has been temporarily pressurized to enable it to hold its shape. The tanks being assembled below still have supporting rings around them. On the final assembly line, the tank will be mated to the propulsion section, and the control, guidance, telemetry, power supply, tracking and other systems will be added. The steel skins of the Atlas missiles are nowhere thicker than 0.040 in.—thinner than a dime.



Radial draw former recently put into operation by Convair stretches a sheet of thin stainless steel to form a section of the Atlas ICBM. The machine produces metal shapes in one piece that previously required welding of several pieces. One end of the metal sheet is clamped in the jaws of the gripper unit on the turntable, lower right. The other end is held in the jaws of the main ram stretching unit, center. With tension maintained between jaws, the table is rotated counterclockwise, wrapping the sheet onto the die. Special contours can also be produced.

Lundberg cuts costs 11% by switching to Timken® hot-rolled seamless steel tubing on National Acme screw machines

TO cut costs, Lundberg Screw Products Company of Lansing, Michigan, investigated the possibility of using hot-rolled tubing on its National Acme screw machines. The question: were hot rolled tolerances adaptable to standard collets.

Timken Company sales engineers suggested they try hand chucking. Although hand chucking would mean a slight increase in time due to minor adjustments of collet tension, the material savings would more than offset the higher labor cost. And it did. The manufacturer found these adjustments added 1/10 of an hour per tube to production time. *But* the saving in material cost was *11%*.

Can hot-rolled Timken® seamless steel tubing save money for you? Call us and see. And to further increase your steel savings, ask Timken Company engineers to recommend the most economical tube size for your hollow parts job. We'll guarantee this size to clean up to your dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of tapered roller bearings, fine alloy steels and removable rock bits.

Timken alloy steel and seamless tubing is available from warehouse stock in 44 cities in the United States. Call your local Timken Company sales office for the name of your nearest Timken steel distributor.

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 417 on Page 19

inside of a wing is itself used as a fuel holder, the system is practical because propellant tanks must be pressurized anyway to aid propellant flow to the rocket engines. After the missile is fueled, helium is fed into the space remaining at the top of the propellant levels. The helium does a dual job. It helps force propellants to the 360,000-lb thrust Atlas engines, and keeps the balloon-like skin drum-tight. The idea was tested in 1948 and incorporated in the present Atlas program at its outset in 1951.

A special cold-rolled austenitic steel (AISI grade 301) was developed for Atlas tanks, as were new welding techniques and fabrication equipment. The steel is noted for its toughness, strength-to-weight ratio, ease of handling, and resistance to heat, cold, and corrosion. It is also easily formed and welded.

The final welding process lasts about 16 hours, during which time two men, a welder and an information-relayer, remain in the tank. The crew is rotated every two hours, the men entering and leaving through a hole. When the job is done and the internal crew and welding arm are out of the tank, a conical section is fitted over the access hole.

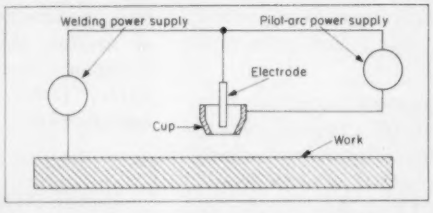
At this point the tank is pressurized and the skin wrinkles disappear. After being pressurized, the tank can be struck heavy hammer blows without permanently indenting the walls.

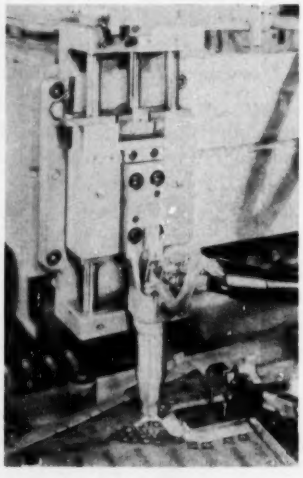
Fabrication equipment developed includes a 93-ton stretch former, the largest radial stretch machine in the United States using a hydraulic-driven turntable. With this machine, designed for Convair by Cyril Bath Co., Solon, Ohio, a 20-ft sheet of stainless steel can be stretched as much as 18 in. Use of the machine permits one-piece fabrication of metal shapes that formerly required the welding together of several pieces. Close control of tension is possible by electronic measurement of metallurgical changes taking place during forming.

Skin gages vary throughout the tank. They are tailored to meet local stresses. Several of the 27 sections are thinner than the wall of a milk carton. The heaviest skin gage is less than 0.040 in.

The tank can be converted to other missions with no change in basic design or welding equipment. Atlas boosters are being built for the Vega, Centaur, Discoverer, and Mercury space programs by merely upgrading the skin gage used in certain areas.

Pilot Arc Gives Positive Starts



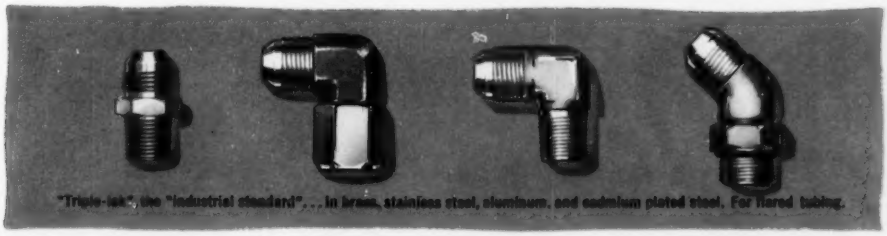


Reliable timing of weld cycles is possible on an automatic shielded-arc welding machine that use a new "pilot arc." The system was developed by Linde Co., division of Union Carbide, New York. Previous methods used high-frequency current which caused erratic firing with cold electrodes. Usual practice was to warmup electrodes with a few spot welds on scrap. In new Heliarc torches, the low-powered (5 amp) pilot arc is established between the tungsten electrode and the inert-gas nozzle surrounding it. This maintains a ball of incandescent gas at the electrode tip, warming the electrode and forming a path for the primary arc to travel to the workpiece. Where torches are fired according to a predetermined schedule, reliability is increased by this method. Electrodes last four times as long if not subjected to high-frequency currents.

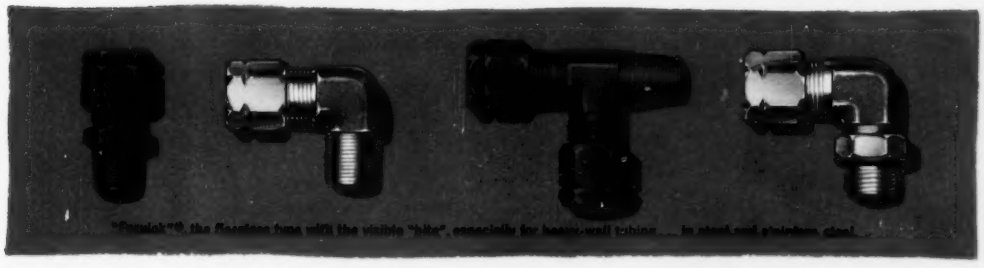
Servospeed
HEART OF AUTOMATION
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL
1/100 — 10 H. P.
Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.
Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989
Circle 418 on Page 19

Circle 419 on Page 19 for Crown line→

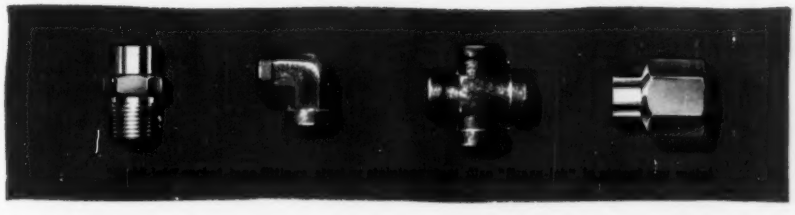
PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS



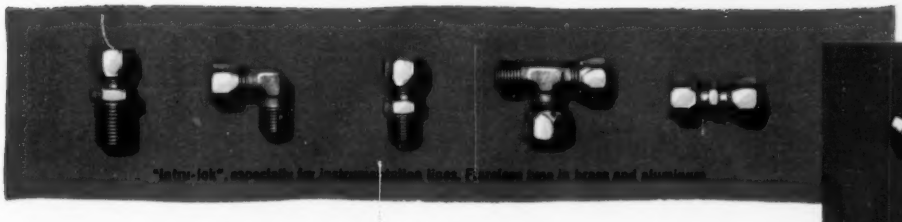
"Triple-lok", the "industrial standard"... in brass, stainless steel, aluminum, and cadmium plated steel. For flared tubing.



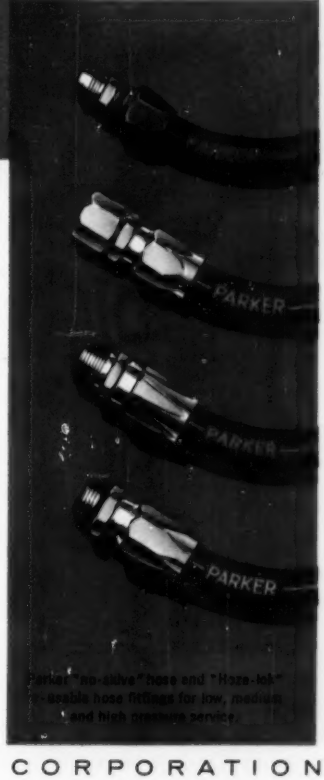
"Ferulok"®, the flareless type with the visible "bite", especially for heavy-wall tubing ... in steel and stainless steel.



"Weld-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



"Intru-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



"Parker" "no-skive" hose and "Hoze-lok" re-usable hose fittings for low, medium and high pressure service.

Only from Parker

such a wide range of fittings...so fast

If it's an industrial fitting, whether for tubing or for hose, Parker has it or can make it, in standard sizes in any metal.

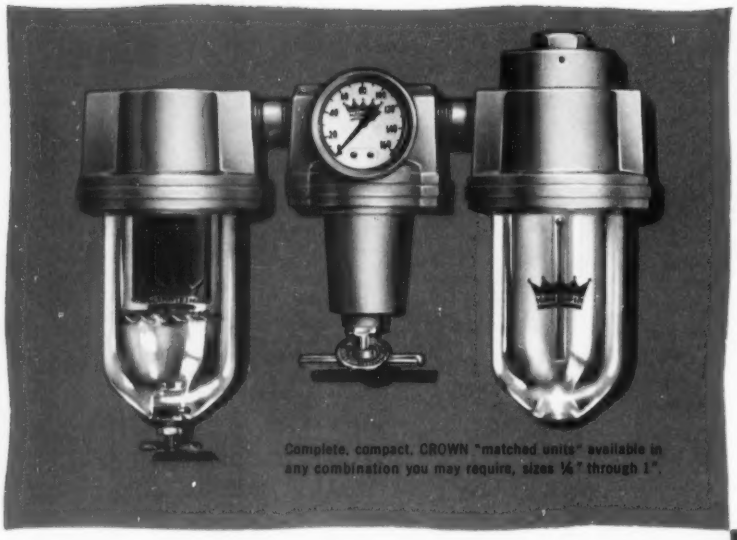
Parker "Triple-lok" for flared tubing . . . Parker "Ferulok"® for heavy-wall tubing . . . Parker "Weld-lok" for high-temperature, high pressure lines. ("Braze-lok", our newest line, does not require an open torch, is for medium temperatures.) "Intru-lok", for copper, aluminum or plastic instrumentation lines, requires no flaring. Parker hose and "Hoze-lok" re-usable hose fittings require no skiving of the hose.

There's a Parker distributor near you, write us for his name . . . call him for Parker catalogs.

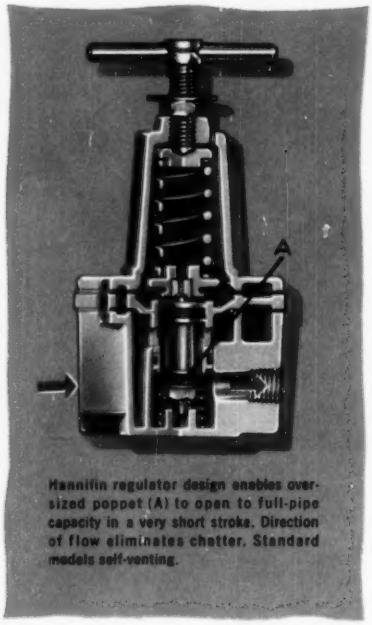
Parker Fittings and Hose Division
17325 Euclid Avenue • Cleveland 12, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION

Crown From HANNIFIN air preparation units that don't waste air power



Complete, compact, CROWN "matched units" available in any combination you may require, sizes ⅛" through 1".



Hannifin regulator design enables oversized poppet (A) to open to full-pipe capacity in a very short stroke. Direction of flow eliminates chatter. Standard models self-venting.

Hannifin CROWN "Combo" units – filters, regulators and lubricators in any combination – keep compressed air in the "pink of condition" without depriving you of needed air flow.

Crown regulators open fast on demand, close precisely when demand is satisfied, deliver the exact amount of air needed. Their "piston balanced" poppet design, which makes possible a flat, large-area, poppet-type valve with very short stroke, is the reason. The inherent stability of this design – no hunting or chatter – results in multi-million cycle life.

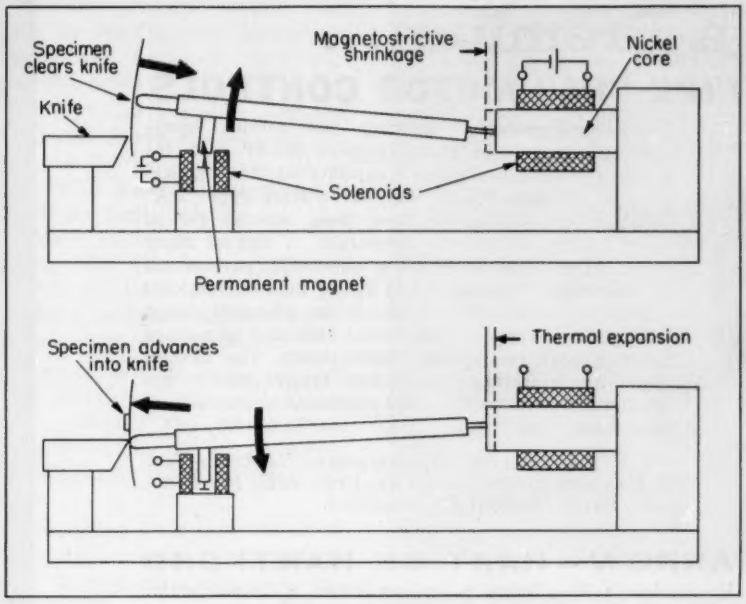
Crown filters have large, reusable filter elements for minimum resistance to air flow. Crown lubricators introduce predetermined amounts of oil into the air stream, automatically. Their design is so responsive to variations in air flow rate that the concealed, tamperproof adjustment is rarely used. This is the easiest lubricator of all to fill, and remote-fill models are available.

Crown units are competitively priced and stocked in principal industrial areas by Hannifin CROWN authorized distributors. For CROWN literature and the name of the distributor nearest you, write:

HANNIFIN COMPANY

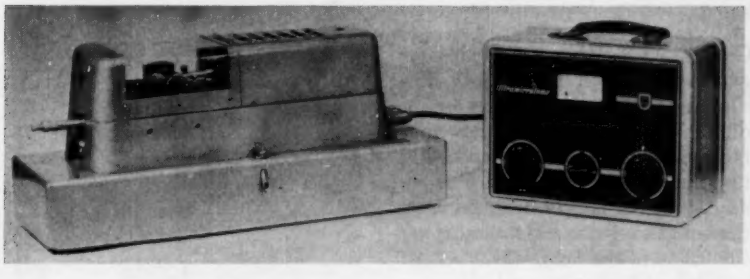
535 South Wolf Road • Des Plaines, Illinois

Lubricator vane (A) is factory pre-set for most applications. Valve (B) shuts off air pressure to bowl when fill plug is removed. This patented Hannifin feature permits bowl refill without shutting down air line.



Microslices by Magnetostriction

Electron microscope specimens 75 angstroms thin are produced with a new magnetostrictive microtone. Developed by Philips Electronics Inc., Mount Vernon, N. Y., the slicer utilizes a permanent magnet, two electro-magnets, and controlled thermal expansion to regulate specimen thickness. With specimen inserted in the metal rod and the knife edge set for the initial cut, power is supplied to the two solenoids. The permanent magnet is repelled, raising the arm. Simultaneous magnetostrictive effect in the nickel core moves the rod away from the knife edge. When power is interrupted, the rod falls and "grows"; the knife then slices a thin section from the specimen. Magnetostrictive shrinkage prevents contact between knife edge and specimen on the up stroke, even though thermal expansion of the nickel core continuously advances the specimen toward the knife edge.



Small Cars: Are They Safe?

ATLANTIC CITY, N. J.—One of the topics discussed at the SAE Summer Meeting was the safety record of the imported car and the expected safety record of the soon-to-be-built American small car.

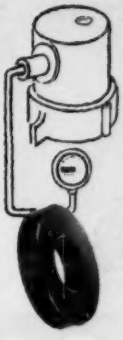
In his talk "Small Cars, Pro and Con," L. E. Crooks, Consumers Union of U.S. Inc., summed up arguments as follows:

"Where the driver makes a mistake in judgment, or is surprised and has to pare down his margin of safety, small cars are more apt than the big cars to have handling characteristics that will support the driver and help him get back to normal. In a word, the small car is more 'forgiving.' The small car is also, by virtue of its superior maneuverability, safer because it can avoid trouble better. Once in an accident, however, the best opinion seems to rule that the small car is

←Circle 420 on Page 19 for Hose and Hose Fittings

HOW CERAMIC MAGNETS ENERGIZE NEW IDEAS

. . . In Liquid Flow Registers



Water and liquid meters can be read at a distance with the remote-indicating "Read-O-Matic" Register of the Badger Meter Mfg. Co., of Milwaukee. Heart of this self-contained generator is an inexpensive 6-pole ring magnet of Stackpole Ceramagnet. The quick release of the magnet under spring tension induces a 3-volt pulse in 6 coils. This is transmitted to a remote totalizer.

. . . In Appliances • Powerful, low cost Ceramagnet ceramic permanent magnets open, close and hold doors; put *snap* into snap-action switches and thermostats; catch lids from can openers . . . make other magnet uses practical for the first time. Ceramagnet requires no keepers; retains magnetism indefinitely, can be molded in practically any shape.

. . . In Automotive Equipment

High coercive force and high electrical resistivity make Ceramagnet ideal as field magnets in small dc motors. They are likewise being investigated for fuel-pump drives, speedometers, ammeters, carburetors, and many other new devices.

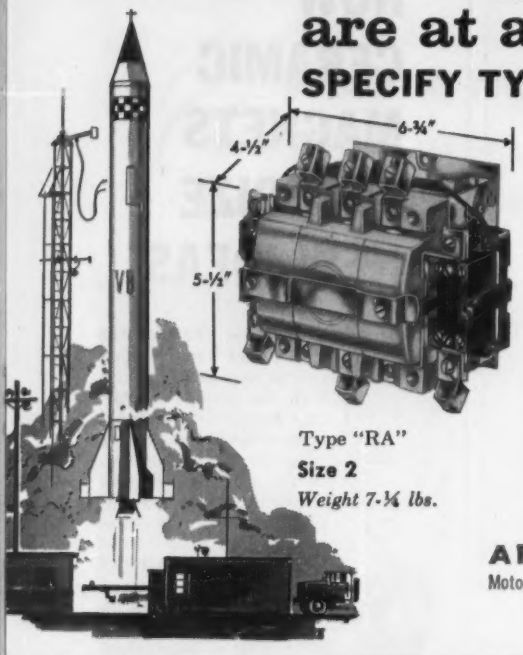
Where can YOU use Ceramagnet? For practical suggestions, and engineering details, write for Stackpole Bulletin, RC-12A. STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE Ceramagnet®
FERRITE PERMANENT MAGNETS

Circle 421 on Page 19

Whenever SPACE and WEIGHT are at a Premium...

SPECIFY TYPE "RA" MOTOR CONTROLS



Type "RA"
Size 2
Weight 7-¼ lbs.

Launching, guidance, tracking and service equipment for rockets or guided missiles ***MUST*** pack the greatest possible performance capacity into the smallest possible envelope. That's why Arrow-Hart Type "RA" Starters and Contactors have been selected for so many rocket and missile projects . . . and so many other applications where space and weight savings are all-important. Far smaller and lighter than conventional types, Arrow-Hart "RA" Controls use advanced design with greatly improved mechanical efficiency to achieve superior performance and dependability. The modern Right Angle operating mechanism insures positive operation and provides increased resistance to unfavorable atmospheric conditions.

For "RA" Data Section, write now to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

ARROW – HART OF HARTFORD
Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 422 on Page 19

ARROW AH HART

going to get the worst of it, though such a conclusion is neither simple to arrive at nor well documented.

"The same may be said regarding the view that the low-powered small car is more dangerous than the high-powered big one because it cannot accelerate rapidly enough, particularly at open road speeds. It can't, all right; but a coin has two sides, and the very fast acceleration built into U. S. cars can lead to trouble, too, especially in the hands of owners less skilled at the wheel than the Detroit proponents of 'acceleration as a safety factor.' Statistics are lacking, but with reference to acceleration this can be said: In driving either the peanut or the powerhouse, safety depends on driver judgment, and I believe it is correct to say that as the relative speeds which must be judged increase, and as the distances at which the perception of relative speeds likewise increase, so also do errors of judgment and errors of perception become more numerous, and consequences more serious."

Coming Next: Infinite Lamp Life?

G.E. Says Iodine-Cycle Biggest Step Since Edison

CLEVELAND — New incandescent quartz tubes will never glow dim thanks to minute quantities of iodine. The traces of iodine gas combine chemically with evaporating tungsten-filament particles. The iodine, plus the lamp's heat, prevents the tungsten from accumulating on the inside of the lamp wall. As the tungsten-iodine compound circulates back to the incandescent filament, heat breaks down the compound and redeposits the tungsten on the filament. The reformed iodine vapor starts the cycle again.

If evaporating tungsten particles could be returned in an even coating, a lamp would theoretically never burn out, say GE engineers. However, life of the Quartzline is more than double that of standard lamps, even though the recoating is not controlled.

Quartzline lamps must be operated horizontally to maintain the iodine cycle. They operate at high

New tubular 1500-watt lamp, right, is 200 times smaller in volume than standard industrial lighting lamp, left. Yet it gives more than 10 per cent more light during its life because it never blackens. An iodine cycle works to catch evaporating particles of the tungsten filament and actually puts them back on the filament before they can cause blackening.

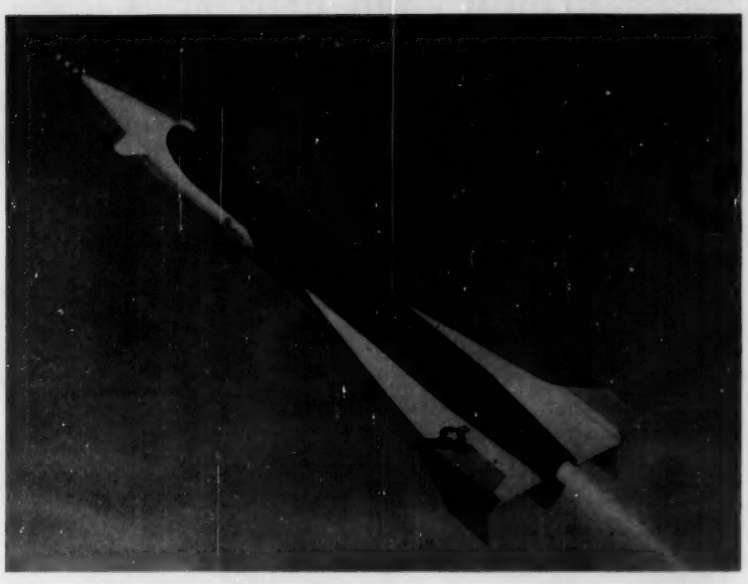
temperatures and require screening to prevent accidental contact. They need no cleaning, since heat of the lamps will incinerate most dust particles settling upon them.

Soon to be available, 500 and 1500-watt lamps—respectively 4½ and 10 in. long—produce 10,500 and 33,000 lumens. Total volume of the larger lamp is 1/200 that of a standard 1500-watt lamp. In addition, the self cleaning General Electric Co. lamps are reported the brightest, and most efficient incandescent lights ever produced.

Because of their small size they lend themselves very well to use with reflectors and other optical controls. Light can be thrown in rectangular or square beams, or in strips.

The iodine cycle principle is already utilized in a wingtip marker lamp for supersonic aircraft.

Since heated quartz tube will not crack or break when suddenly exposed to ice or cold water, the rugged lamps withstand a wide range of temperatures and thermal shocks. Accordingly, a variety of jobs for the lamps is predicted.



Sparring Partners for Missilemen

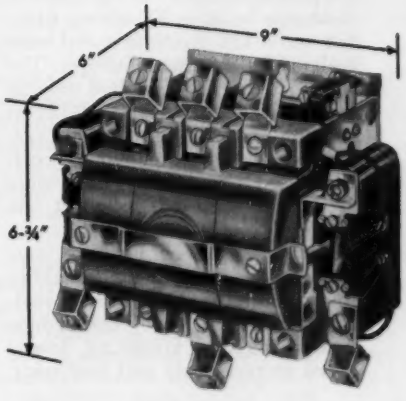
Economical missile targets with speed and altitude performance comparable to enemy aircraft will provide target practice for Air Force and Navy pilots firing radar-guided and heat-seeking air-to-air missiles. Developed by Beech Aircraft Corp., Wichita, Kansas, the drones will fly at any predetermined altitude from 5000 to 70,000 ft. Duration of flight will be five minutes at Mach 2, or 8 minutes at Mach 1.5. Powerplants are based on a liquid-rocket propulsion system with dual thrust chambers for climb and cruise.

MOTOR CONTROLS

SMALLEST Magnetic Starters Available!

Arrow-Hart Type "RA" Motor Controls feature the advanced design "Right Angle" mechanism, with the magnet operating through a simple bellcrank mechanism. This provides a mechanical advantage making possible a much smaller and lighter magnet which out-performs older, direct-acting types. As a result, size and weight are reduced by almost half, while performance, operating efficiency and dependability are greatly improved. Other important "RA" design features include extra-rugged silver cadmium alloy cadmium contacts with positively guided travel for perfect alignment . . . and straight-thru wiring for simplified circuit design.

Arrow-Hart offers you the *only* complete line of smaller, lighter motor controls including: NEMA Sizes 0 through 5, in across-the-line, reversing and two-speed starters and contactors.



Type "RA" Starter
Size 3
Weight 15-½ lbs.

Write for free 16 page booklet of Motor Control Wiring Diagrams: The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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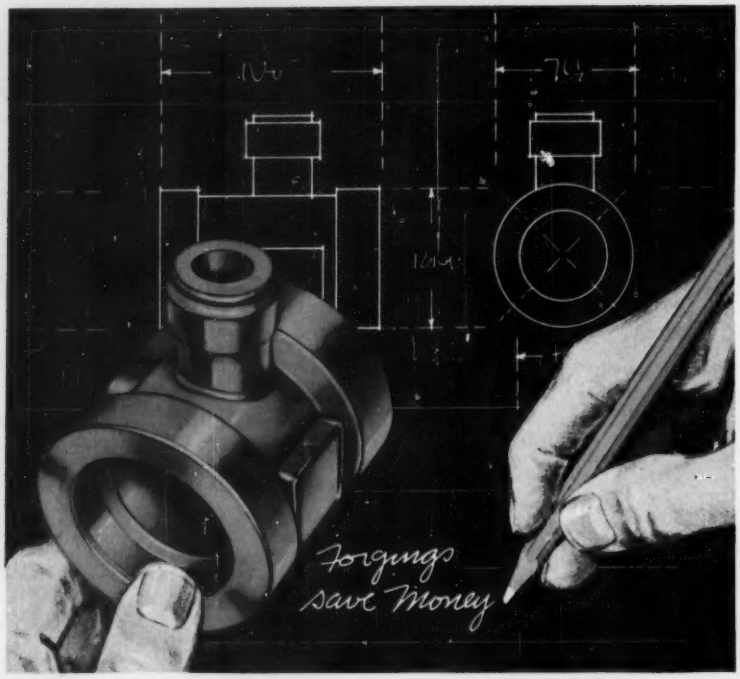
Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 423 on Page 19

DESIGN YOUR PART AS A BRIDGEPORT CORED FORGING

SAVE MATERIAL . . . SAVE LABOR



You can design efficiency and savings into your product with Bridgeport Cored Forgings.

For example, by switching from a solid forging to a cored forging in the production of a fire-extinguisher discharge head, a 20% saving in labor and a 45% saving in metal were realized by one manufacturer. The cored forged part weighed only 2½ lbs. versus 4½ lbs. for the solid brass forging. This weight advantage, along with lower machining costs when new combination tools were used, was achieved with just one stroke of the forging press!

Bridgeport Cored Forgings give your metals components qualities unequaled by any other metal-forming method. They can reduce machining and finishing, lower metal requirements and tool costs. Stronger parts and components without flaws can be designed to eliminate assembly operations. All these design advantages bring new efficiency to your part and production methods.

A book on the subject, "Bridgeport Forgings," is yours for the asking. Write Dept. 8903.

CORED FORGING DIVISION

BRIDGEPORT BRASS COMPANY

1000 Connecticut Ave., So. Norwalk, Conn.

Specialists in Metals from Aluminum to Zirconium

Meetings

AND EXPOSITIONS

Aug. 9-12—

American Society of Mechanical Engineers - American Institute of Chemical Engineers. Heat Transfer Conference to be held at the University of Connecticut, Storrs, Conn. Further information may be obtained from Meetings Dept. ASME, 29 W. 39th St., New York 18, N. Y.

Aug. 10-13—

Society of Automotive Engineers Inc. International West Coast Meeting to be held at the Hotel Georgia, Vancouver, B. C., Canada. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

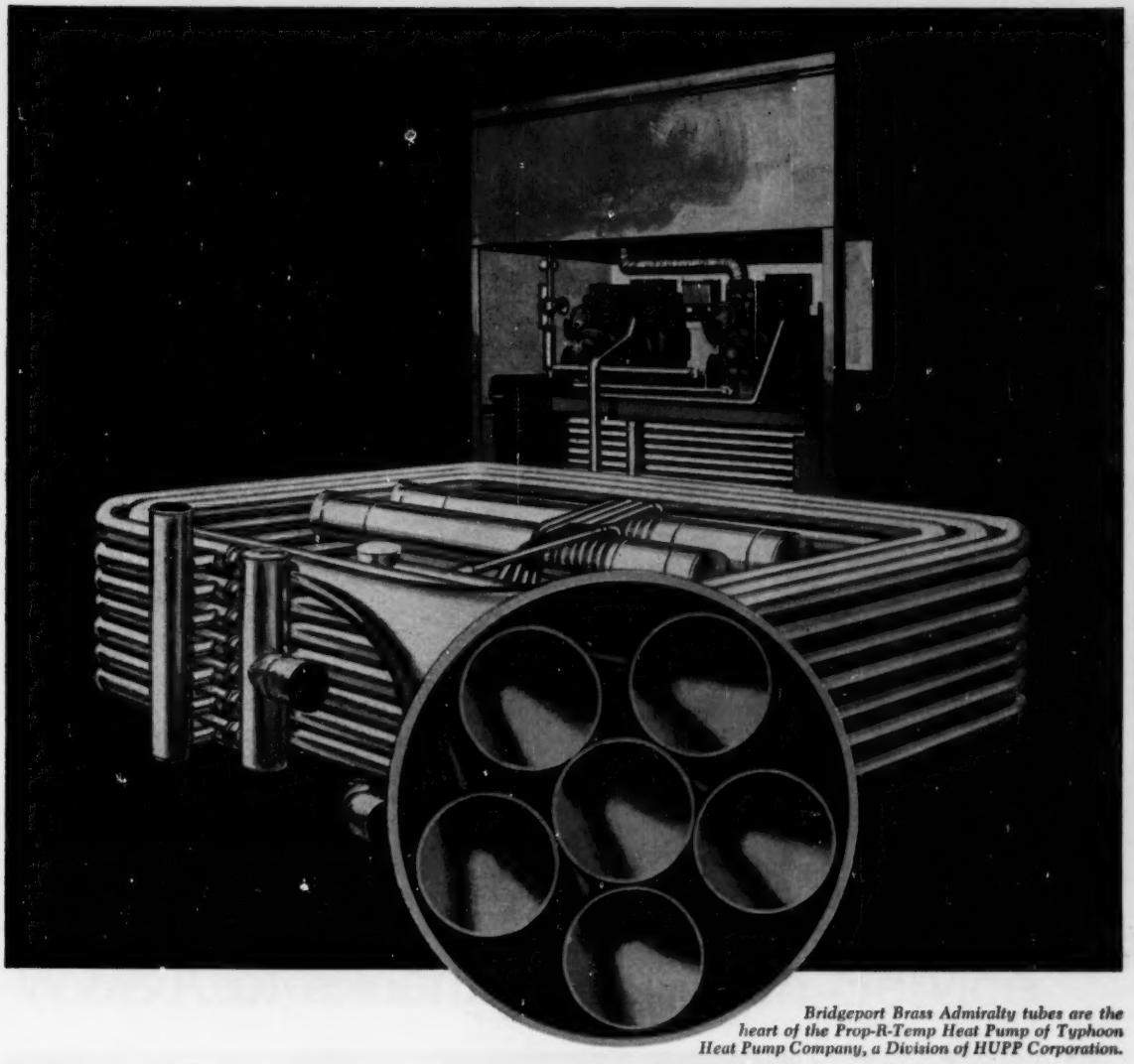
Aug. 17—

Institute of Radio Engineers. First National Ultrasonics Symposium to be held in San Francisco. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Aug. 18-21—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Sponsors are Western Electronic Manufacturers Association and the Seventh Region of the Institute of Radio Engineers. Further information can be obtained from WESCON headquarters, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

"Our speaker this evening is a leading authority on missiles and space travel."



Bridgeport Brass Admiralty tubes are the heart of the Prop-R-Temp Heat Pump of Typhoon Heat Pump Company, a Division of HUPP Corporation.

1,000 HEAT PUMPS PROVE THE DEPENDABILITY OF BRIDGEPORT TUBES

This remarkable Prop-R-Temp Heat Pump, a product of Typhoon Heat Pump Company , Tampa, Florida, heats, cools and dehumidifies. A key part of this unit is the tube-in-tube condenser coil which transfers heat from water to refrigerant, or reverse. This unique circular or rectangular coil consists of six ⅝" O D Bridgeport Admiralty tubes nestled inside a larger, 1⅜" O D Admiralty tube. The six smaller tubes are inserted into a straight length of larger tube and then coiled or bent on blocks of various radii. This fabricating method requires closely controlled physical properties of tube to avoid distortion. The length and number of coils—whatever their size—is subjected to a test of 1,000 lbs. pressure before being accepted for application.

Years ago, trouble was frequently experienced due to copper tube failure or excessive scaling caused by highly corrosive waters in certain localities. This failure was costly since,when it occurred, it was necessary to replace the entire condenser.

Bridgeport came up with the answer—Admiralty tubes. Since the switch, over 1,000 Typhoon heat pumps have gone into service without one instance of tube failure due to corrosion in sizes varying up to 1,000,000 BTU's.

Here again is an example of how *standard* Bridgeport alloys overcame *special* fabricating and corrosion problems. It's also an example of why it pays to take advantage of Bridgeport's outstanding metals know-how. Call in the Man from Bridgeport, today. There's a Sales Office near you. Or write to Dept. 4304.

BRIDGEPORT BRASS COMPANY

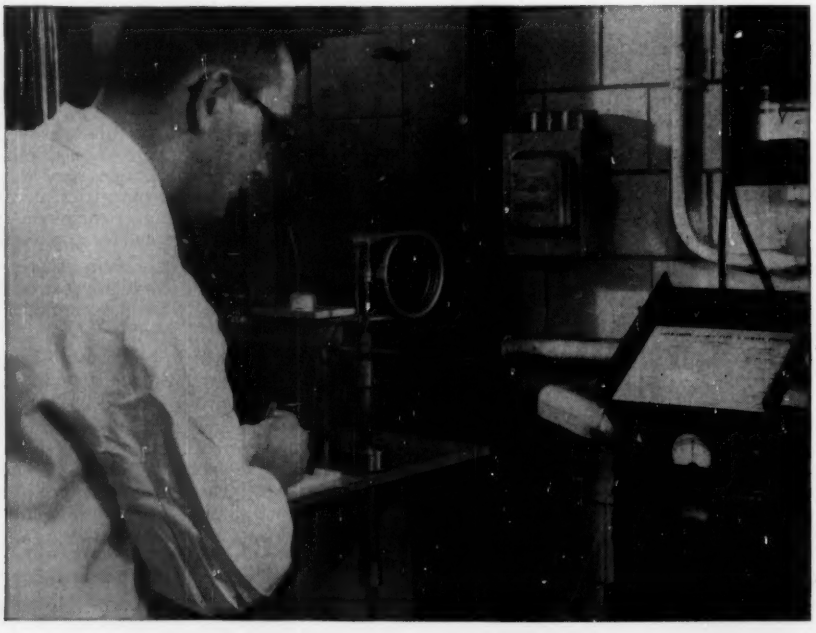
Bridgeport 2, Connecticut • Sales Offices in Principal Cities

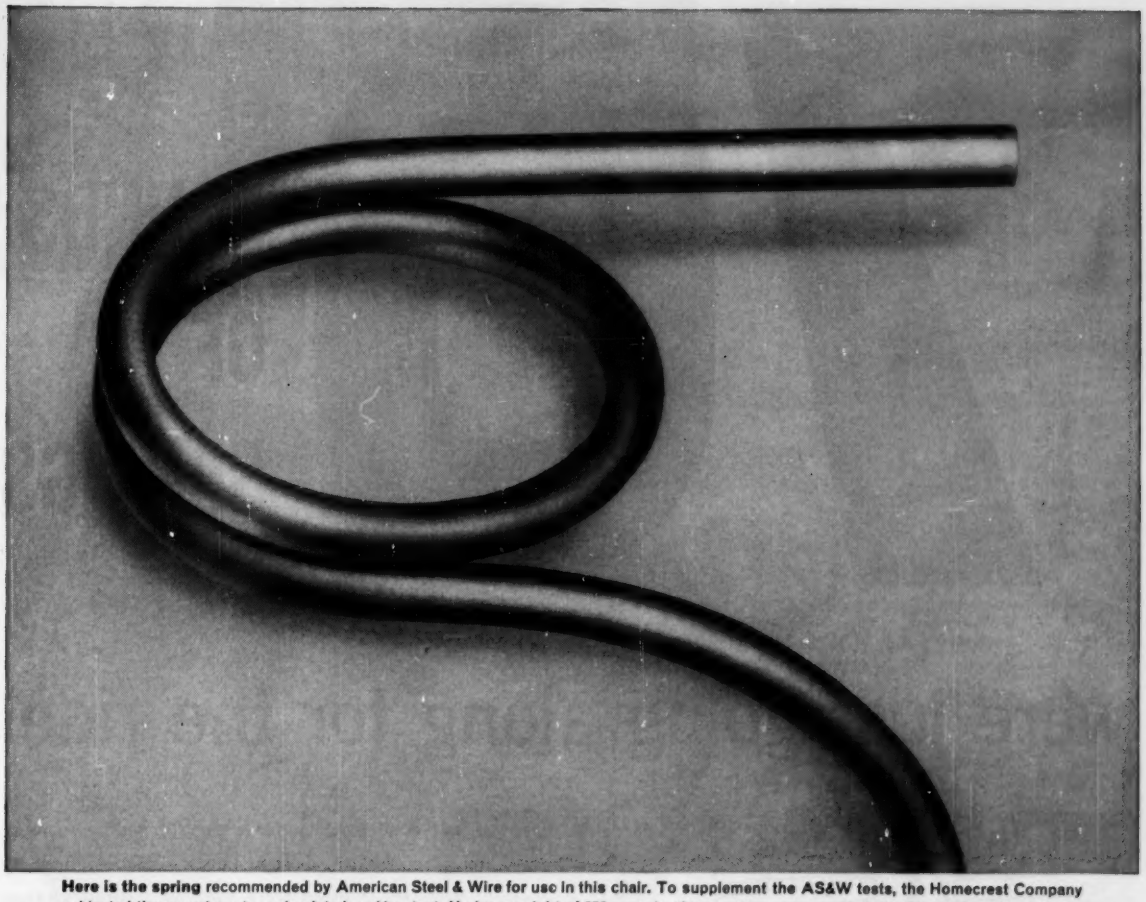
Specialists in Metals from **A***luminum to* **Z***irconium*

20,000 chairs rock on USS American Springs without one failure

...thanks to AS&W

In the American Steel & Wire Spring Testing Laboratory, the springs recommended for the Homecrest Chair go through extensive tests. This Fatigue machine, by means of strain-gauge verification, simulates years of use in a relatively short testing time.





Here is the spring recommended by American Steel & Wire for use in this chair. To supplement the AS&W tests, the Homecrest Company subjected these springs to a simulated rocking test. Under a weight of 250 pounds, these springs were rocked 750,000 times, without failure.

Spring Engineering Research Service

The Homecrest Company, Wadena, Minnesota, wanted to add a swivel rocking chair to their line of modern, functional home furniture. However, they would produce this chair only if it could be a quality item that would give good, dependable service. While designing the chair, they checked with the American Steel & Wire Spring Engineering Consulting Service. The engineers studied the problem, ran extensive tests and finally recommended a pair of round wire helical single coil torsion springs. Using these springs, Homecrest designed, fabricated and marketed the chair. Today 20,000 of these chairs have been sold and not one failure of an AS&W Spring has been reported.

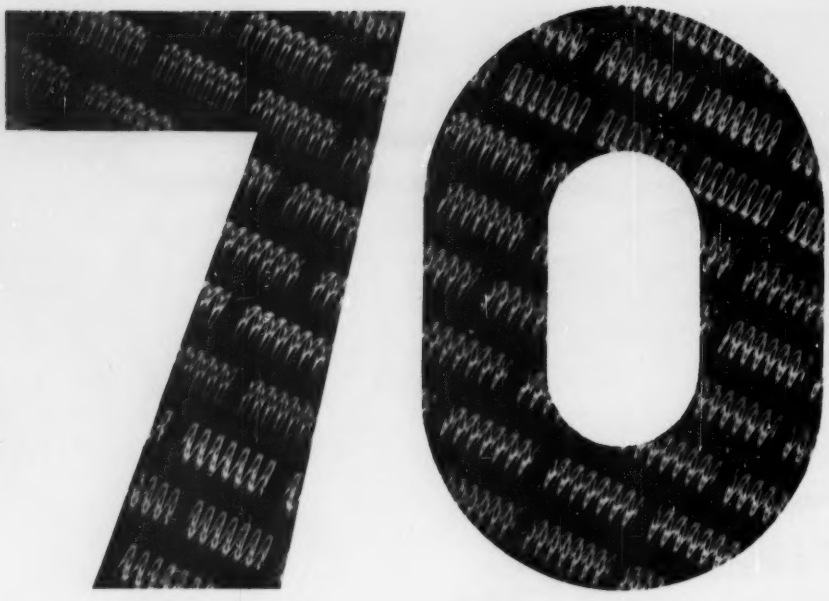
Mr. A. L. Englemann, a partner of Homecrest Company, says, "We have purchased from American Steel & Wire over 45,000 springs, and not one has been reported a failure. We couldn't be happier with American Steel & Wire as a supply source for our springs."

If you have a spring problem, or would like advice on the use of springs in your product, get in touch with any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels, from steel chemistry through product application, to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.*

USS and American are registered trademarks

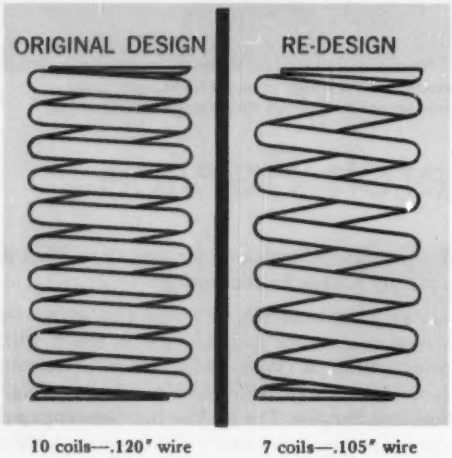
American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad



70 POUNDS OF SPRINGS

were just going along for the ride!



10 coils—.120″ wire
130 lbs. of wire per
1M springs

7 coils—.105″ wire
60 lbs. of wire per
1M springs

Because of mounting cost conditions, a user of motor-support springs asked for a complete design check. Redesigned by A.S.C. engineers, required stresses were met by a slight change in wire size, allowing a reduction in number of coils from 10 to 7. This meant a saving of 70 pounds of material per thousand springs. Because of the shorter length of wire, coiling and grinding speeds were increased, heat-treating time reduced. Saving to the customer—40%.

How about the springs you use? A consultation on your specifications costs you nothing. Just contact any Division of Associated Spring Corporation. For a handy reference to spring action, write for "Spring Design and Selection—in brief."

8904

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
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Ohio Division, Dayton, Ohio
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Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Circle 428 on Page 19

NEW... adjustable 3/4" Deceleration Valve

Simplifies Cam Design, Cuts Set-up Time, Eliminates Need for Special Valve Spools

These Features are Important to You:

- Controlled deceleration regardless of flow rate
- Reduces set-up time—eliminates experimenting with cam shapes
- One valve can handle all applications from 5 to 25 gpm giving greater flexibility
- Regulates initial deceleration pressure—eliminates wasted spool movement
- Can be used for applications to 60 gpm without malfunction
- Includes adjustable by-pass needle valve
- Available with or without check for reverse free flow
- Threaded ports or subplate mounting

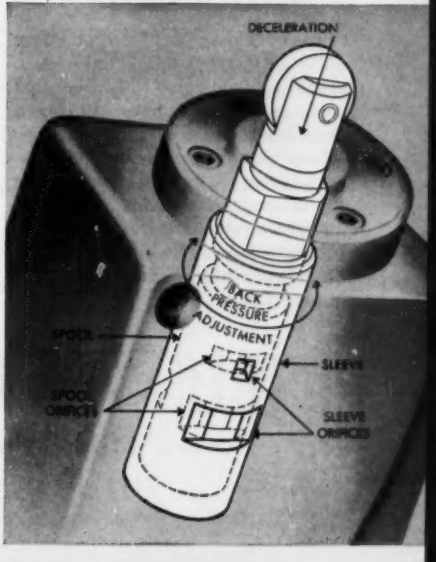
TYPICAL USES:

1. Converting rapid traverse motions to slow, controlled feeds.
2. Rotary indexing operations. Will control deceleration and permit creep to accurate final position.
3. Straight-line transfers. Deceleration control gives smooth stop without excess movement of part being transferred.

Write for installation drawings No. 214322 and I-214323.

Orifice size (through spool and sleeve) is made larger or smaller by rotation of sleeve. Adjusting screws on the face of the valve rotate the sleeve to the required orifice opening. Deceleration stroke length remains unchanged. No special cam shape is required for valve spool travel.

Patent Pending.



VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
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8276

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 429 on Page 19

Design Data on Resilient Clutch Facings

3

FRICTION MATERIAL "FADE" IN CLUTCH APPLICATIONS

Friction material "fade"—progressive and permanent loss of coefficient of friction—becomes a problem in many clutches as increased torque and design changes impose greater loads on the clutch facings.

Effects of Fade

Over long periods of service, excessive fade can change the performance characteristics of the clutch. As friction value decreases, obviously, torque capacity is reduced. And the period of slip during engagement may increase, resulting in loss of the desired engagement characteristics. Increased slip may also cause the clutch to overheat.

The underlying causes of fade are not yet thoroughly understood. However, it has been demonstrated in the laboratory that two factors, temperature and pressure, strongly influence the extent to which a friction material will fade. Most materials lose their friction value faster under high closing pressures. Continuous high operating temperatures normally have a similar effect.

Controlling Fade

All friction materials fade to some degree—some more than others. Thus, for any given set of service conditions, controlling fade becomes a matter of selecting the proper facing.

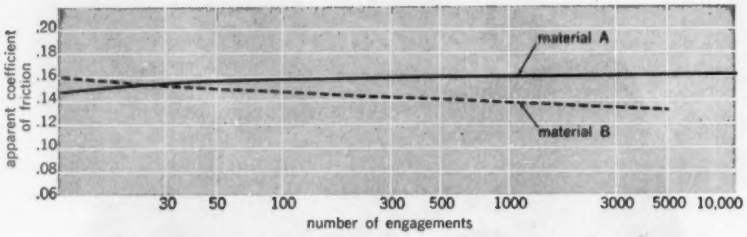
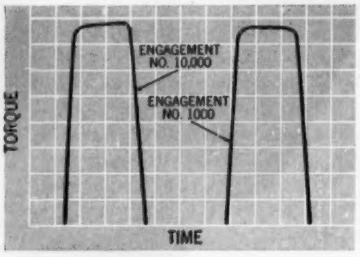


Figure 1. These fade curves were produced in tests covering 10,000 engagements on the Armstrong Wet-Friction Dynamometer. As the graph illustrates, Material B shows considerable fade. But for Material A (Armstrong FM-52) the coefficient of friction is virtually constant.

Figure 1 compares the fade resistance of two different resilient friction materials. Ideally, of course, both curves would be horizontal. The curve for Material B shows a considerable loss of coefficient of friction while Material A much more closely approaches the horizontal. Material A is a new Armstrong facing developed specifically for high fade resistance.

Figure 2 compares torque curves for Material A near the beginning and at the end of a series of engagements. They are nearly identical, indicating engagement characteristics remained practically unchanged.

Figure 2. Torque curves were recorded periodically during this series of tests. The curves for engagements 1000 and 10,000 are shown below.

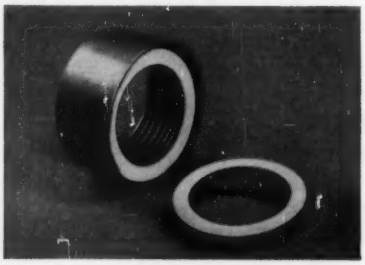


ACTUAL USE SUBSTANTIATES RESEARCH FINDINGS

At right is a clutch pack from a modern automatic transmission. The friction material is Armstrong FM-52, one of a new group of facings developed especially for this type of application.

These new materials are made by an exclusive patented process that combines organic and inorganic fibers with special synthetic saturants. The resulting compounds combine smooth engagement with high torque capacity and long wear.

Some of these materials are used under closing pressures of 400 psi and ambient temperatures above 300° F.,



and they retain their original performance characteristics for the life of the transmission.

These Armstrong fiber friction materials have been used widely in automatic transmissions since their introduction in 1957.

. . . . . .

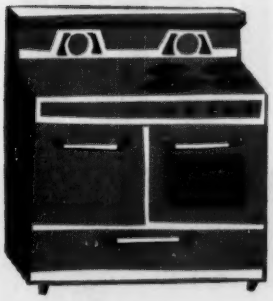
For assistance in selecting the right resilient friction material for your application, send complete details to Armstrong Cork Company, Industrial Division, 7206 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

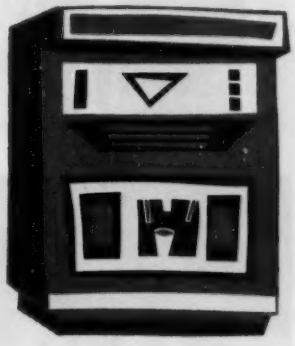
. . . used wherever performance counts

Looking for a bright idea for your product?

LOOK TO BROWN LIPE CHAPIN



HOME APPLIANCES



VENDING MACHINES

BUSINESS MACHINES

MUSIC & COMMUNICATIONS

An experienced source of decorative and functional die castings and stampings!

Consider Brown-Lipe-Chapin when you're planning ways of adding "hard sell" to your product. Brown-Lipe-Chapin, with extensive facilities for die casting, metal stamping—including steel and aluminum, and electroplating, can help give your product distinctive new eye appeal with a new dimension in durability.

YOU GET A CREATIVE APPROACH

Brown-Lipe-Chapin, experienced in providing the mass-consumer field with quality bright work, takes a creative approach to your design problems. An experienced staff of engineers work out the best and most economical method of producing your parts.

YOU RECEIVE CONSTRUCTIVE ASSISTANCE

You can count on Brown-Lipe-Chapin for constructive suggestions that often add up to savings in time and money. They'll tackle your most difficult part . . . even if it's up to six feet in length. And complete facilities for die casting, steel or aluminum stamping, anodizing, electroplating and painting are all under one roof.

YOU BENEFIT FROM RELIABILITY BY BROWN-LIPE-CHAPIN

You're assured of reliability with Brown-Lipe-Chapin . . . *reliability* in step-by-step quality control, work performed by craftsmen who are experienced in meeting the rigid specifications of the automotive industry . . . *reliability* in meeting your delivery schedules right on time . . . *reliability* in facilities that can be quickly converted to model change-overs . . . and *reliability* as a continued source of supply. Brown-Lipe-Chapin will guarantee to supply your requirements for die casting and stamping for as long as you may want to specify.

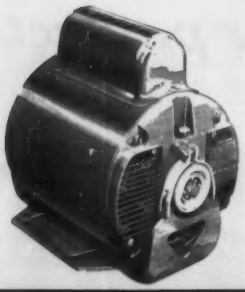
Brown-Lipe-Chapin's two plants, in Syracuse, New York and Elyria, Ohio, combine 25 acres of modern plant facilities that are ready to go to work for you now. So, before the die is cast on your product designs, contact Brown-Lipe-Chapin, Division of General Motors Corporation, Syracuse, New York.

GM GENERAL MOTORS

RELIABILITY by BROWN·LIPE·CHAPIN

DIVISION OF GENERAL MOTORS CORPORATION

Circle 430 on Page 19

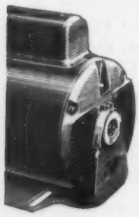


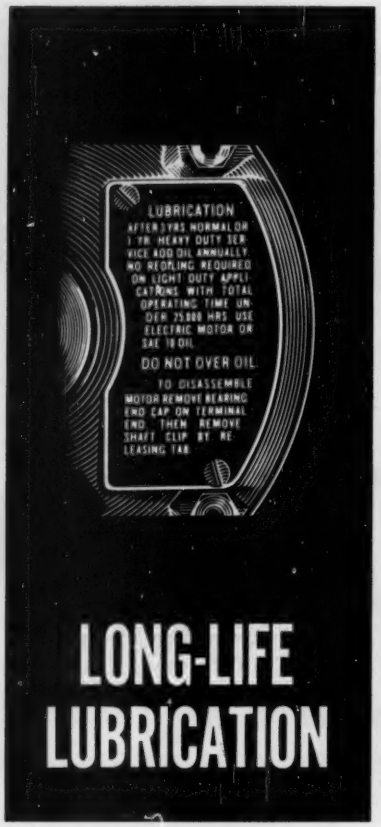
General Electric RELIABILITY

RUST-RESISTANT SHAFT

New protective shaft finish resists rusting, looks better, lasts longer

General Electric Form G motors feature a special gun-metal-like treatment of the shaft which resists rust and corrosion. Fans, pulleys, and couplings are easy to remove. Even endshield latches and hardware now are bright plated to last longer, look better. G-E Form G motors assure you the extra life and easy maintenance your customers want!

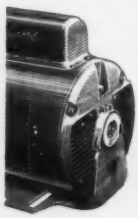



LUBRICATION
AFTER 3 YRS NORMAL OR 1 YR HEAVY DUTY SERVICE ADD OIL ANNUALLY NO REOILING REQUIRED ON LIGHT DUTY APPLICATIONS WITH TOTAL OPERATING TIME UNDER 25,000 HRS USE ELECTRIC MOTOR OR SAE 10 OIL
DO NOT OVER OIL
TO DISASSEMBLE MOTOR REMOVE BEARING END CAP ON TERMINAL END THEN REMOVE SHAFT CLIP BY RELEASING TAB

LONG-LIFE LUBRICATION

Large oil supply and superb retention system cut maintenance

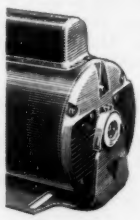
Form G motors require little reoiling and on some applications no reoiling at all. This results from a 50% larger oil reservoir plus a highly efficient method of retaining oil. (On G-E ball bearing motors, a special long-life grease gives up to 10 years' service without relubrication.) Another good reason for you to choose General Electric Form G's!



ACCURATE ALIGNMENT

Sturdy, disk-type endshields assure accurate bearing alignment

General Electric Form G's feature disk-type endshields, heavily ribbed for high rigidity and long life. The rabbet and bearing are placed in the same plane and machined simultaneously to provide inherent bearing alignment. Form G endshields won't warp! Accurate, permanent alignment means longer bearing life and dependable motor operation.

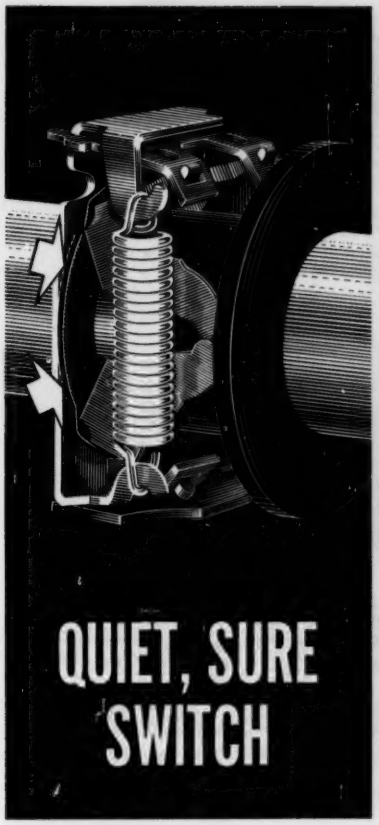


GENERAL ELECTRIC GENERAL ELECTRIC GENERAL ELECTRIC

JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER

Form G motors provide field-proved

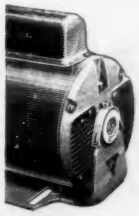
YOU CAN COUNT ON



QUIET, SURE SWITCH

Dependable centrifugal switch gives quiet, positive snap-action

The centrifugal switch on Form G's is designed to stand up to heaviest demands (3,500,000 test operations). Add to this a switch that's quieter than ever. A carefully designed composition washer greatly reduces start-stop click without sacrificing positive snap action. Here's another Form G difference that means more satisfied customers for you!

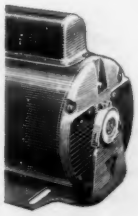


GENERAL ELECTRIC

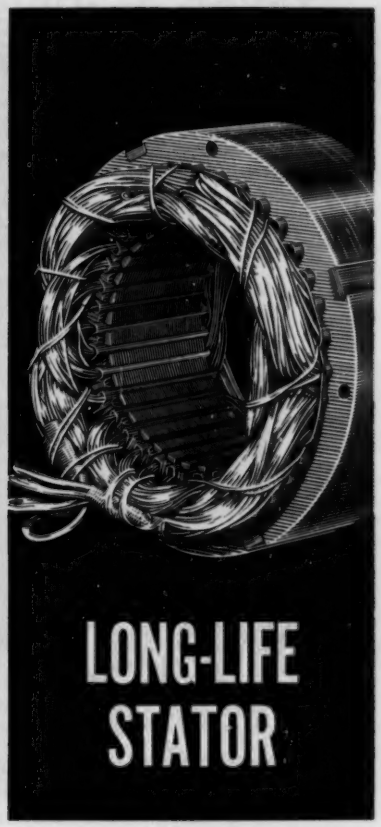
THRUST PROTECTION

Washer assembly absorbs thrust from any direction; contributes to longer life

A specially-designed three-piece thrust washer assembly, keyed to rotate with the shaft, withstands normal thrust from any direction, regardless of motor angle. It also acts as an oil seal to help provide positive oil retention, contributing to longer lubrication life and reduced maintenance. If you're looking for a motor that's built to last, try Form G!



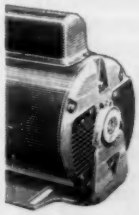
GENERAL ELECTRIC



LONG-LIFE STATOR

Heavy-duty bonding dip and stator clamps provide rigid, uniform assembly

Along with the Mylar*-Formex** insulation system pioneered by G.E., you now get a new bonding treatment on Form G motor stators. It affords added protection against stress. Stator cores are now specially clamped for highly accurate alignment. These new features result in extra rigidity, more uniform quality. Here's longer motor life!



*Reg. trade-mark, DuPont Co.
**Reg. trade-mark, G.E. Co.

702-91

GENERAL ELECTRIC

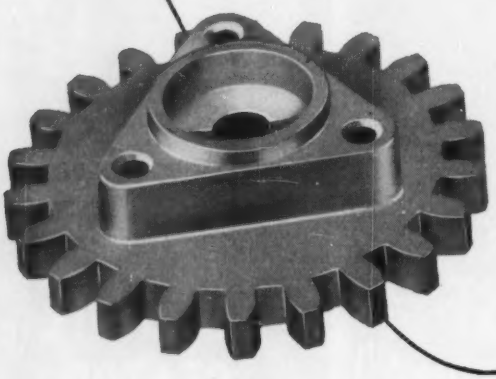
ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES

Circle 433 on Page 19

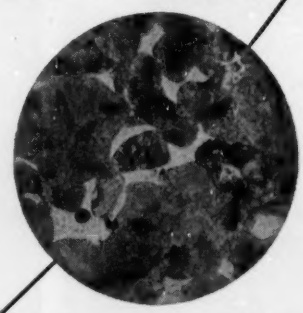
Quality of GRAMIX® precision parts

insured by metallurgical control in the laboratory

proven by performance on the job!



Photomicrograph of a section of an inferior powder metallurgy part that has been improperly sintered. Structure is composed of cementite and ferrite.



Photomicrograph of an internally sound GRAMIX part shows the fine grain structure of tough, shock-resistant pearlite.

To assure the dependable performance of GRAMIX powder metallurgy parts in actual operation, the United States Graphite Company combines exacting laboratory tests and rigid production controls to insure the quality of every GRAMIX part. Through the use of the metallograph, for example, GRAMIX engineers can check the internal structure of a part. A comparison of the photomicrographs shown above readily shows the sound under-the-surface quality of a GRAMIX part as opposed to the poor internal composition of an improperly sintered part. In the photomicrograph at the top, notice the cementite between the ferrite grain boundaries. This cementite will tend to break up and rupture under shock. The surface of the material is decarburized and only remnants of pearlite remain. *This condition is due entirely to the lack of adequate sintering control!*

The photomicrograph of the GRAMIX part at the bottom shows a fine grain pearlite structure that's tough, strong and wear resisting. Absolute sintering control along with precise metallurgical control in the laboratory is utilized by The United States Graphite Company to positively assure quality GRAMIX parts.

Write today for these helpful engineering manuals. Engineering Bulletin No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 contains facts about GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy. Get your copies now.

X-264-1R

THE UNITED STATES GRAPHITE COMPANY

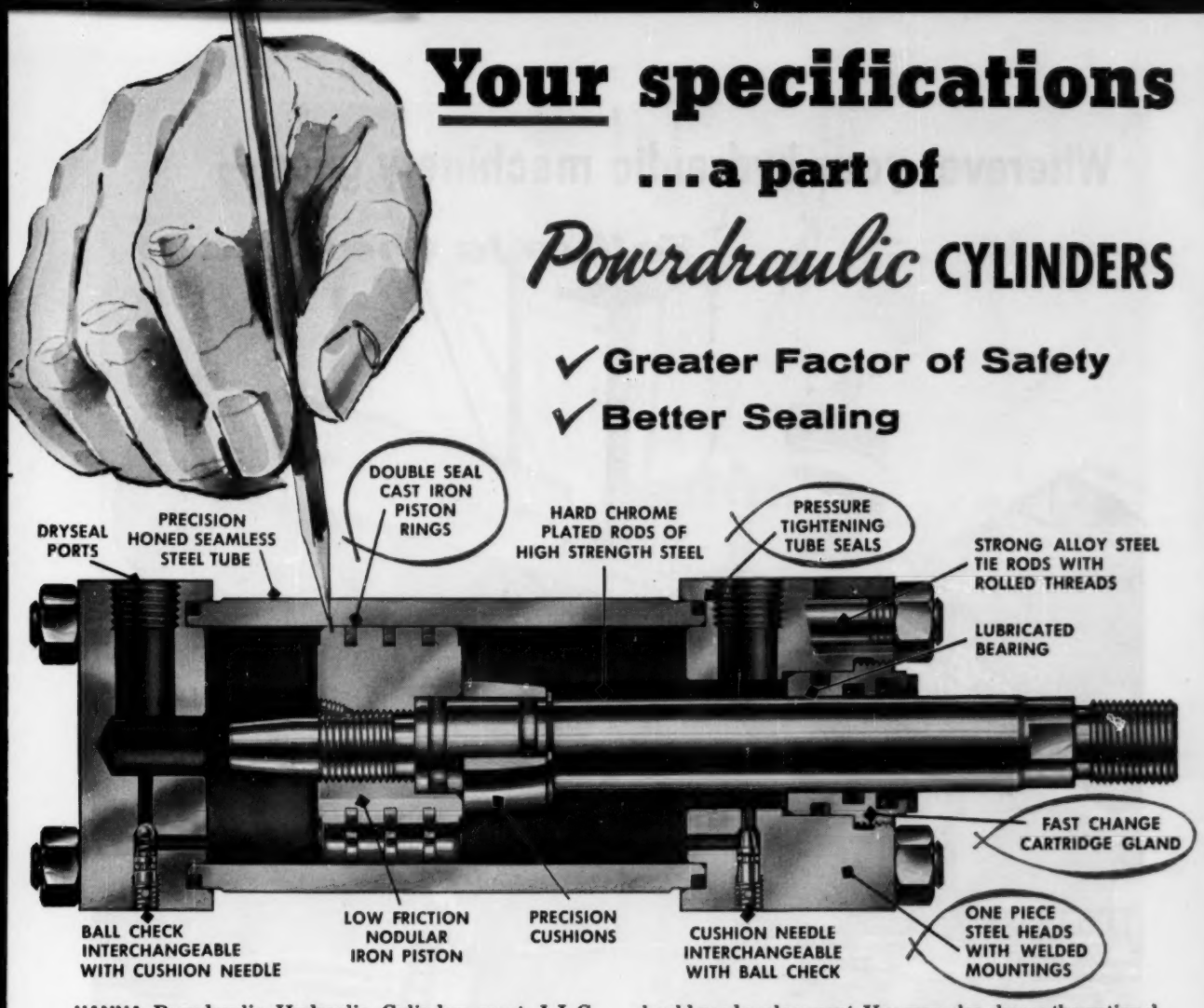
DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Your specifications ...a part of *Powrdraulic* CYLINDERS

✓ Greater Factor of Safety

✓ Better Sealing


DRYSEAL PORTS
PRECISION HONED SEAMLESS STEEL TUBE
DOUBLE SEAL CAST IRON PISTON RINGS
HARD CHROME PLATED RODS OF HIGH STRENGTH STEEL
PRESSURE TIGHTENING TUBE SEALS
STRONG ALLOY STEEL TIE RODS WITH ROLLED THREADS
LUBRICATED BEARING
FAST CHANGE CARTRIDGE GLAND
ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS
CUSHION NEEDLE INTERCHANGEABLE WITH BALL CHECK
PRECISION CUSHIONS
LOW FRICTION NODULAR IRON PISTON
BALL CHECK INTERCHANGEABLE WITH CUSHION NEEDLE

HANNA Powrdraulic Hydraulic Cylinders meet J. I. C. recommendations and have industry standard mounting dimensions—2000 psi and 3000 psi non-shock. 1½″ through 8″ bores.

EXCLUSIVE PRESSURE TIGHTENING TUBE SEALS, located on the outside diameter of the cylinder tube, form a positive seal at all pressures from zero to maximum. Minute expansion of the tube due to pressure, squeezes the "O" ring making the seal even tighter. The "O" ring is fully confined between the head and the tube and will not extrude at high pressures. Unlike other cylinders that seal at the tube ends or inside diameter, the Hanna Powrdraulic Cylinder with pressure tightening O.D. seals will remain tight at all pressures.

DOUBLE SEAL PISTON RINGS give you twice the sealing power of conventional piston rings. These bi-directional, cast iron rings, consisting of a ring within a ring, seal both the "in" stroke and the "out" stroke of the cylinder. The piston with double seal rings is packed for life and never should need replacement. You may also choose the optional piston with "U" type synthetic packings.

FAST CHANGE CARTRIDGE GLAND equipped with a leak proof, low friction rod seal forms a tight seal from zero to maximum pressure. Built in rod wiper removes dirt and particles from piston rod as the rod moves "in" and serves as another hydraulic seal to wipe the rod dry on the "out" stroke. You can select either the standard gland or the optional, multiple lip, spring loaded seal. The optional gland is interchangeable and is available with synthetic rubber or Teflon* Vee packing.

ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS are much stronger than conventional bolted construction and assure squareness of mountings. All mountings are designed to carry maximum cylinder loads with a generous safety margin.

Write for Catalog 900 and the name of your nearest representative.

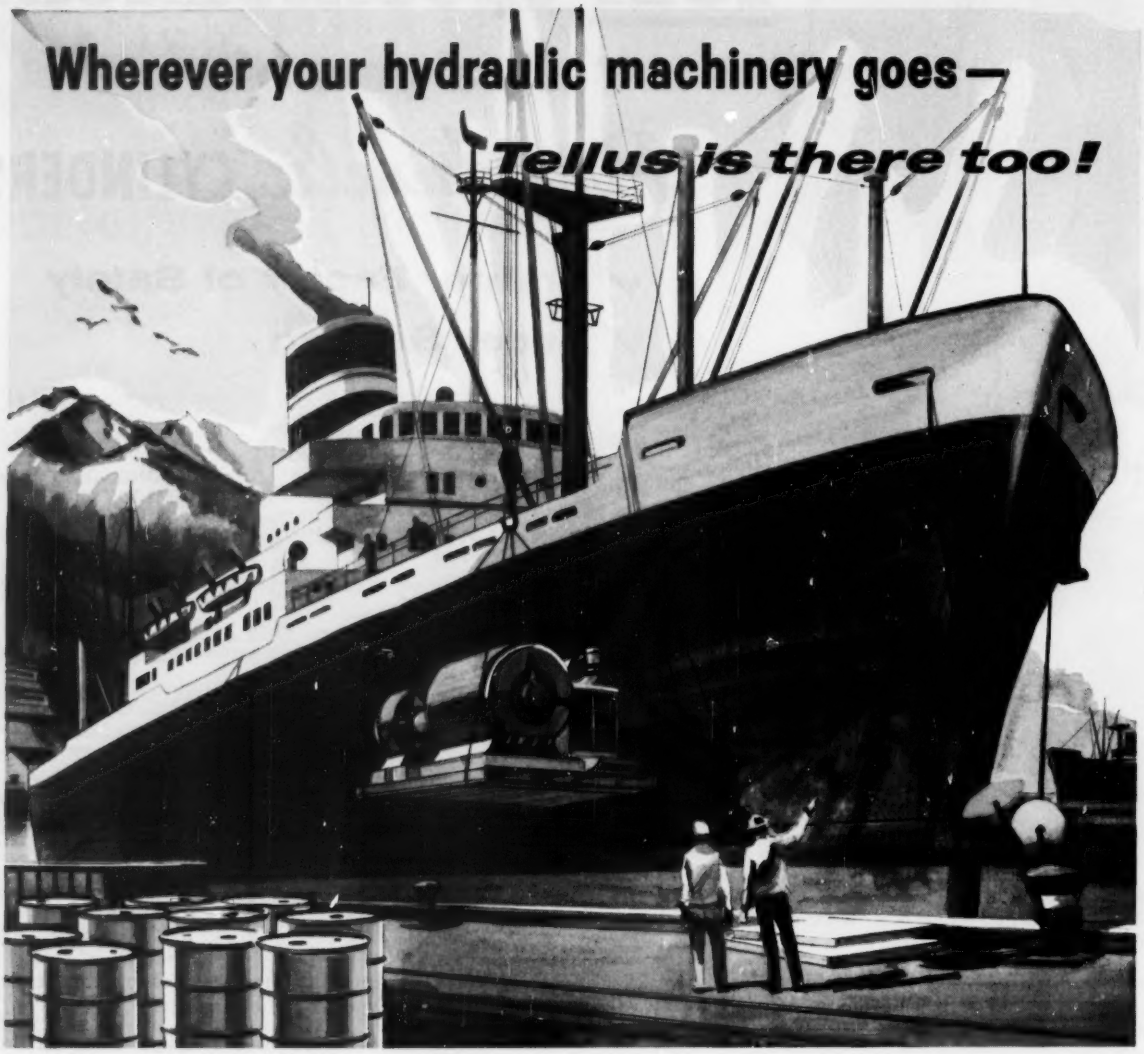
*DuPont's registered trademark.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT... CYLINDERS ...VALVES

1751 Elston Avenue • Chicago 22, Illinois

Circle 435 on Page 19



Other Outstanding Shell Industrial Lubricants

Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

Its performance and name are the same around the world

Shell Tellus Oil is available to your customers abroad. Because of this world-wide availability, they can enjoy the same performance that your domestic customers rely upon.

Tellus® Oil is top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

Wherever your hydraulic machinery goes, make Tellus Oil your standard recommendation.

For more complete information, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

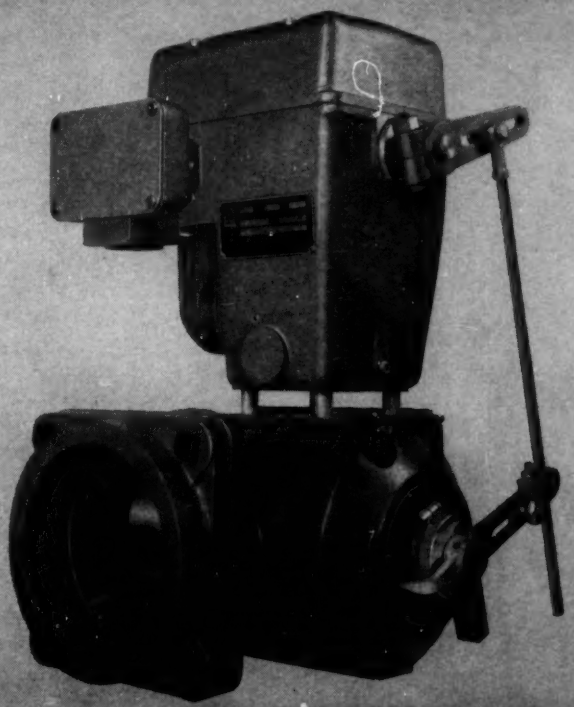
SHELL TELLUS OIL

the performance-proven hydraulic oil

SHELL

Circle 436 on Page 19

Power, ruggedness and accuracy for modern electric control systems



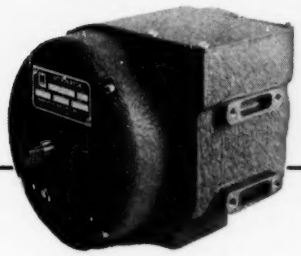
New INDUSTRIAL VALVE MOTOR SERIES 831E

Honeywell's new Industrial Valve Motor for valve or damper operation . . . for applications requiring maximum power and ruggedness . . . high accuracy and reproducibility of control.

This new, powerful motor is available for on-off, 2-position, floating or proportional control. Its features include:

- **EXCEPTIONALLY HIGH TORQUE**—up to 62.5 foot pounds.
- **FAST SPEEDS WHEN NEEDED**—from 3 to 120 seconds—full travel.
- **INTERNAL BRAKE**—provides exact positioning without coasting, holds load in any position when de-energized.
- **EASY ADJUSTMENTS**—internal limit and auxiliary switches easily accessible and adjustable in the field.
- **ARC SUPPRESSION**—circuit protects contacts of controllers and relays.
- **PROPORTIONAL CONTROL**—models have over-travel protection for the slidewire.

For complete details on the new Series 831E Industrial Motor, write for Specification S-804-2, or call your nearby Honeywell field engineer. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.



ACTIONATOR* Series M630-M930

Gives dependable, low-cost service where the application calls for medium power.

Operate valves, dampers, louvers and other final control elements with this rugged, lightweight industrial motor. It's available with on-off, two-position, floating or proportional control. Its features include:

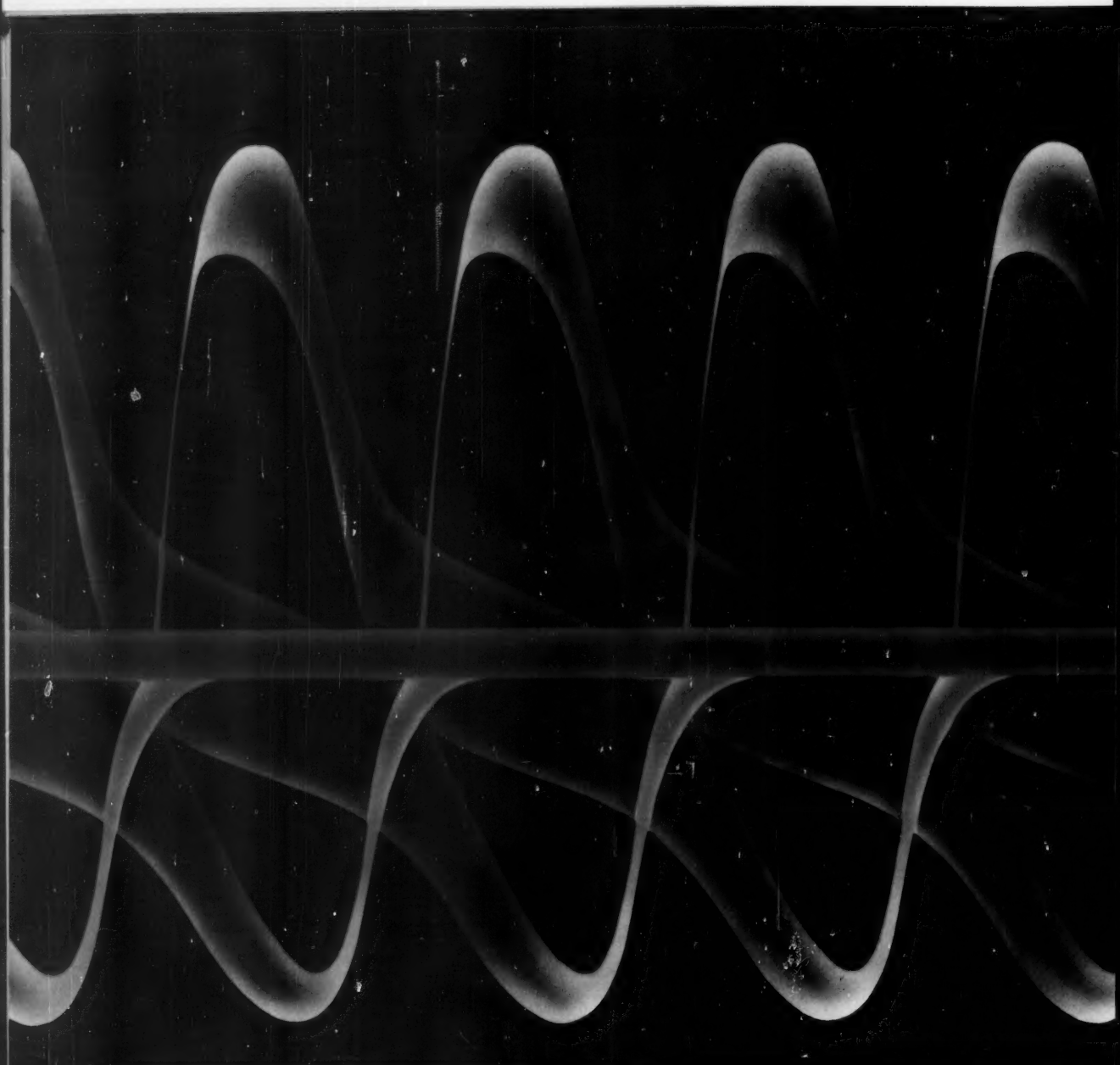
- **High torque ratings**—to 200 inch-pounds.
- **Fast speeds** available to meet application requirements.
- **Internal brake** to hold load in any position without coasting or hunting.
- **Easy adjustments**—readily accessible, field adjustable, cam-operated travel and auxiliary switches.

For details, write for Specification S-804-3, or call your nearby Honeywell field engineer.

**Tradename Minneapolis-Honeywell Regulator Co.*

Honeywell

First in Control



The cathode ray oscilloscope is one of science's and industry's most perceptive instruments for determining uniformity of operation. The pattern reproduced here is a harmonically modulated sine wave of exact uniformity.

Uniformity is Malleable

Just as the input of an oscilloscope can be controlled to produce repetitive patterns, so can consistently uniform metal parts be produced with Malleable iron because of modern, scientific controls. The unique method by which all Malleable castings are made and the exacting techniques employed by Malleable foundries assure Malleable users of castings that are uniform, part after part, regardless of size or shape. This uniformity, combined with unparalleled physical and mechanical properties, ideally suits Malleable castings for modern America's quality products.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER

MALLEABLE CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Better Products at Lower Cost Result From Malleable Uniformity Controls

Uniform quality — whether for five or five million pieces — is essential to maintain product quality and increase manufacturing efficiency. With accelerating frequency, Malleable castings contribute their unique uniformity in critical applications where durable, reliable components are necessary.

Key to Uniformity is Control

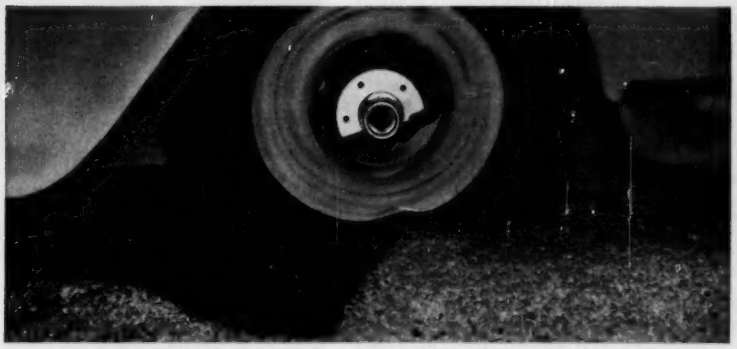
Malleable iron is produced under closely controlled manufacturing techniques. From charge composition and molding sand properties, through final inspection, every critical factor is held constant by using the most modern techniques of metal analysis, process control and inspection.

Internal Uniformity

This versatile engineering material is achieved through converting the base white iron into tough Malleable iron by a controlled heat treating process. Malleable's internal structure exhibits excellent uniformity, an important factor in assuring the dependable performance of intricately designed components.

External Uniformity

Fundamental to the casting process is the ability to produce a given shape, time after time, in either small or large quantities. Metal can be placed exactly where it is needed . . . eliminated where it is not. Good design — achieved through close cooperation between the customer and the foundry — can assure the necessary tolerances and the lowest possible finished part cost. Modern techniques of production and inspection are used to insure top quality, dimensionally accurate castings.



The life of every motorist rides in complete safety on Malleable wheel hubs of unerring uniformity.

Uniformity Proven by Use

The final test of any part is how well it stands up in actual service. Under continuous cyclic and shock loading, the millions of Malleable wheel hubs, which are in service on the front end of every American-made car, have compiled an enviable record of proven uniformity. Another dramatic example of Malleable's uniformity is proved in the old adage "A chain is only as strong as its weakest link." Miles of Malleable chain, carrying tremendous loads year after year without failure, demonstrate the uniformity of every cast link.

New techniques for controlling every element of Malleable production are the result of intensive research done by Malleable foundries in their continuing search for ways to make Malleable even more versatile and indispensable to industry.

More Information Available

Your copy of *Data Unit 103—Uniformity* — is available from any member of the Malleable Castings Council. If you prefer, write direct to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
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NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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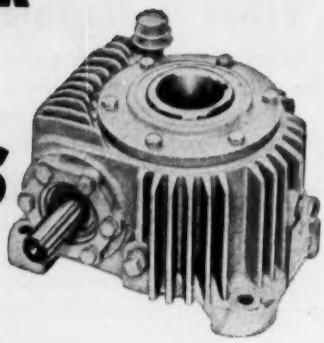
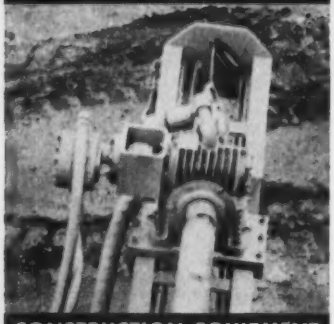
CONE-DRIVE WORM GEAR HOLLOW SHAFT SPEED REDUCERS

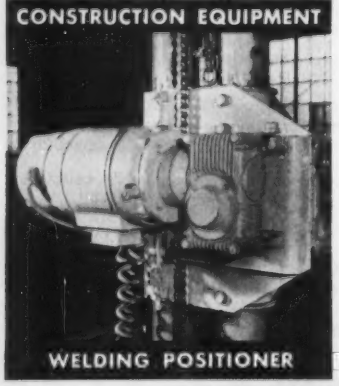


provide greater flexibility in the design of your equipment

MIXING MACHINE



CONSTRUCTION EQUIPMENT



WELDING POSITIONER

Standard Cone-Drive hollow shaft speed reducers are available in four basic sizes (2, 2½, 3 and 3½ inch center distance units) to accommodate loads from fractional to 13 horsepower. They are built around the double-enveloping worm gear design and carry the same high ratings as standard Cone-Drive speed reducers.

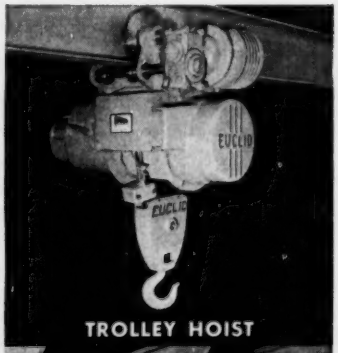
You, as a designer, will be particularly interested in the versatility of application and space savings made possible by the right angle design between input and output shafts.

The reducer is mounted directly on the driven shaft and requires only a simple bracket or torque arm to prevent it from rotating about the driven shaft.

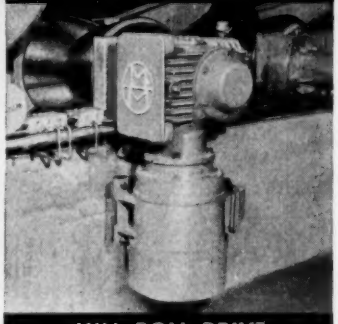
Construction is rugged enough to permit floor or wall mounting of Cone-Drive hollow shaft reducers and "hanging" the driven shaft on it (in certain applications), eliminating pillow blocks or bearings. Larger-than-necessary taper roller bearings and heavy-duty castings make this possible.

If a motorized reducer is desired, a simple, standard bell housing can be furnished for NEMA C-type face motors. The need for expensive couplings is eliminated since a tang-type drive sleeve and suitably machined worms are provided. When a hollow-shaft speed reducer and face-mounted motor are combined, no bed plate or mounting arrangement is required. Pulleys, belts, sheaves, etc., that might be troublesome or difficult to install are also eliminated.

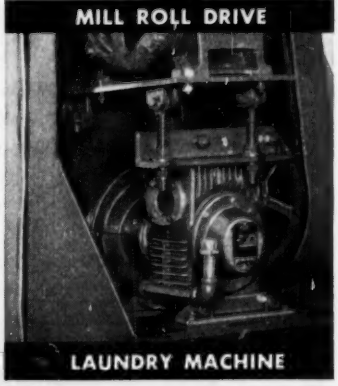
Ask for Bulletin CD-218.



TROLLEY HOIST



MILL ROLL DRIVE



LAUNDRY MACHINE

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

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DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

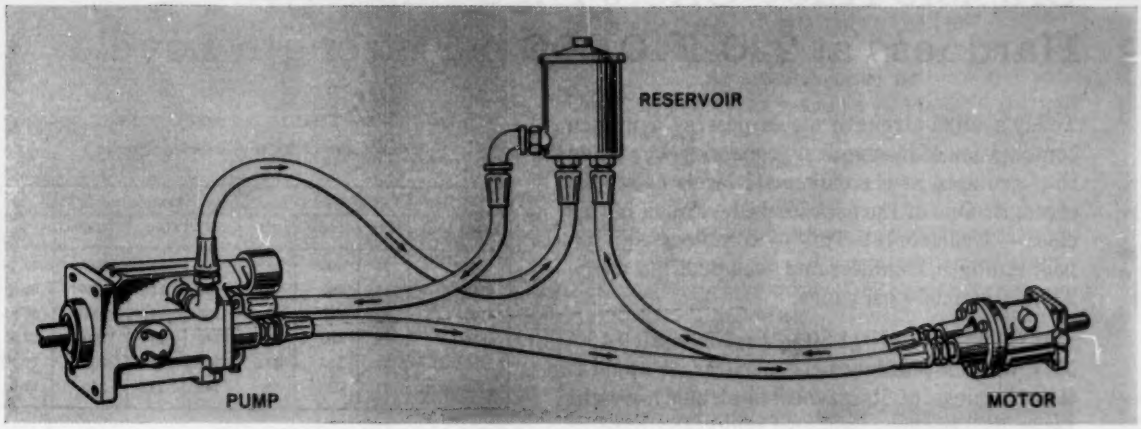
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

Creative hydraulics by Sundstrand

Variable input—constant output speed transmissions designed for mobile equipment

Compact, lightweight, highly efficient hydrostatic transmissions develop up to 9 hp



32 PV Variable Displacement Pump

Reservoir 1½-Quart Capacity

7MC Fixed Displacement Motor

Here's a new idea in boosting efficiency of constant output speed auxiliary operations on mobile equipment. Compact, high-efficiency hydrostatic transmissions designed to use low-cost piston-type pumps and motors are being introduced in six standard sizes by Sundstrand—a company with more than 10 years' experience in constant speed drives.

Principal components of the Sundstrand hydrostatic transmission as shown at the left are: (1) Variable displacement axial piston pump, (2) a fixed displacement axial piston motor, and (3) a small (1½-quart) reservoir. Output horsepower depends on input speed range (see table at right).

Motor speed remains constant within ±5% despite variations in pump input speed because of the unique control. The pump continually measures its own output and makes adjustments automatically in order to deliver a constant flow of oil.

By adding a small independent manual control to the circuit, pump delivery may be regulated to vary output speed of the motor from zero to maximum RPM. Constant motor output speed is maintained at any particular valve setting.

System is unusually compact and light in weight. There's no spilling of oil over a relief valve or bypassing of oil under pressure as pump delivers only the amount of oil needed. High efficiency is obtained—therefore there is no problem of heat dissipation.

Typical Hydrostatic Transmissions

OUTPUT H.P.	PUMP INPUT SPEED RANGE—RPM	MOTOR CONSTANT OUTPUT SPEED RPM ±5%*
2 hp	300 to 3000	1200
3 hp	450 to 3000	1800
4 hp	600 to 2500	2400
6 hp	800 to 2400	3000
8 hp	850 to 2300	3300
9 hp	950 to 2200	3600

*Under normal rated load conditions, motor output speed can be held constant within ±5%.

Typical applications for Sundstrand hydrostatic transmissions include: Alternator drives on construction and firefighting equipment, refrigeration compressor drives, fan drives in air conditioned buses, and conveyor drives on agricultural, construction and mining equipment.

Sundstrand hydrostatic transmissions can be the answer to your power requirements. Get more facts by sending a brief outline of your needs to address below.

SUNDSTRAND

SUNDSTRAND HYDRAULICS

DIVISION OF SUNDSTRAND CORPORATION

2210 Harrison Ave., Rockford, Ill.—Eastern Sales Office: 89 Summit Ave., Summit, N. J.

AIRCRAFT AND INDUSTRIAL HYDRAULIC TRANSMISSIONS, PUMPS, MOTORS AND VALVES • OIL BURNER PUMPS • AIR SANDERS • LATHES, MILLING, BROACHING AND SPECIAL MACHINES • BROACHING TOOLS • MAGNETIC CHUCKS • PACKAGING MACHINERY

Circle 440 on Page 19

Memo on Metals

Crucible Alloy Offers High Impact Strength, Hardness at 220-240,000 psi Strength Levels

Today's ultra-strength steels possess a unique combination of mechanical properties even when they are used at their ultimate levels of tensile strength. One of the first steels developed in this class — Crucible HY-Tuf® — combines high impact strength, hardness and good ductility at the 220,000/240,000 psi range.

HY-Tuf (1.8% Ni, 1.30% Mn, 1.50% Si, 0.40% Mo) was first widely used in aircraft applications because of its favorable strength-weight ratio. But, because it is also tough and hard, it has rapidly found its way into power-driven garden tools, hand- and power-operated banding machines, rock bit bodies, cutter head bolts, couplings, pinion gears and shafts.

HY-Tuf's high impact strength, especially at high levels of tensile strength or hardness, has been demonstrated in a great number of tests. These tests prove HY-Tuf definitely superior to standard AISI alloy steels in impact strength and ductility at hardnesses above 42 Rc or tensile strengths above 190,000 psi. For specific comparisons, see Figures A and B.

FIG. A—TENSILE AND IMPACT DATA

Grade	Temper	Rc	Tensile Strength, psi	.2% Yield Strength, psi	.01% Yield Strength, psi	% Elong. in 2 in.	% Red. of Area	Izod Impact Ft-Lb
HY-Tuf	550F	46.5	234,000	193,000	154,000	13.1	49.7	31
4340	700	46	228,000	212,000	210,000	11.2	47.8	17
4140	800	46	227,000	205,000	198,000	11.2	39.4	8
9442	700	46	225,000	203,000	200,000	10.3	43.4	11

Oversize .505" dia. tensile specimens and finish machined Izod specimens were oil quenched from the conventional austenitizing temperatures and tempered as indicated.

FIG. B—MAXIMUM IMPACT PROPERTIES
(at hardness of Rockwell C45 or greater)

Grade	Izod			Tension Impact			
	Ft-Lb	Temper	Rc	Ft-Lb	Elong.	Temper	Rc
HY-Tuf	33	400F	47.5	195	16	None	47.5
4340	13	860	45	158	12.2	400F	55
4140	17	500	52	160	14	375	55
8630	19	400	51	148	14	200	52.5
4130 (oil)	17	500	47.5	133	14.5	200	50
4130 (water)	21	450	50	142	13.0	200	52.5

The alloy's superior ductility is shown by these slow bend tests performed on ⅞" rod bars heat treated to 47 Rc.

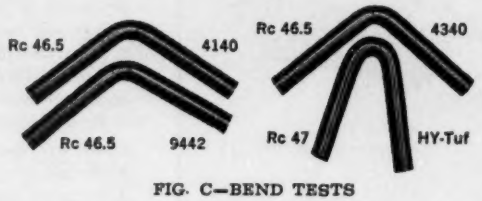
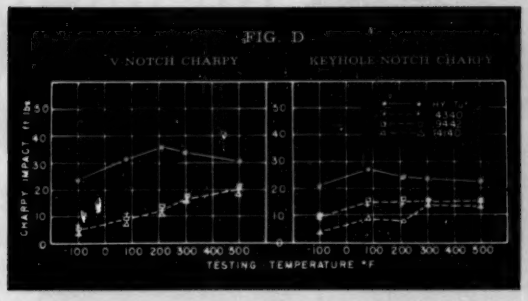


FIG. C—BEND TESTS
Bars — ⅞" rd.

HY-Tuf's notch sensitivity is much lower than that of conventional steels at hardnesses of 45 to 47.5 Rc. Unlike other alloys, HY-Tuf has higher impact values for the V-notch Izod test than for the keyhole Charpy test. This is important because it means that HY-Tuf is much less sensitive to a notch at high strength levels than ordinary steels.

Crucible HY-Tuf conforms to MIL-S-7108 and AMS 6418 and is available in commercial sizes and quantities. For more information on this ultra-strength alloy, send the coupon.

* *ultra-strength steel's impact strength, hardness*
* *titanium price reductions*
* *permanent magnet handbook*



Effect of testing temperature on the notch impact values of HY-Tuf and conventional steels heat treated to 47 Rc.

New Low Prices of Titanium Mill Products Justify Using The Alloy in More Applications

Early this year Crucible's Titanium Division announced new price reductions for its titanium mill products – that cut these prices to *a new industry low*. The reductions, as much as 25%, affected both base prices and the costs of "extras".

For example, sheet was cut from $9.10 per pound base price to $7.50. Strip was reduced $1.25 per pound to $7.25. Plate, formerly $6 per pound, now costs only $5. Crucible also slashed billet prices to $3.55 per pound and wire to $5.50 per pound. Bar items were reduced $1.00 per pound to $4.25 (base price). In addition, some size "extras" were reduced as much as 55%, and finished "extras" by over 40%.

Because of these lower prices, engineers can now utilize titanium's unique properties in many more applications and justify the selection economically. (Even at previous prices, titanium often proved itself the low-cost metal on a cost-per-service-year basis.) This should prove especially true in processing applications requiring corrosion resistance and long-service life, and in aircraft and missile applications where high-strength, lightweight materials are essential.

During the past five years, titanium fabricating costs have also been cut substantially because of experience gained in forging, machining, welding and forming. *For detailed information on Crucible titanium mill products, send the coupon.*

Permanent magnet handbook: 346 pages of design data

One of the most comprehensive manuals ever published on permanent magnets is available through Crucible Steel Company.

The *Permanent Magnet Handbook* contains all the data needed to design magnets into generators, meters, compasses, chucks, couplings, hi-fi and television components, and thousands of other products. It also contains entire sections on permanent magnet measurements, ferromagnetism, magnetization, demagnetization and electro-magnetic theory. It gives the complete performance and property data of over 60 different magnet materials: such as, magnet steels, Alnico alloys, and Ferrimag ceramics.

To cover actual printing costs, a nominal sum of $10.00 is being charged for each copy. However, this sum also covers the cost of additions to the handbook – mailed to subscribers each time new Crucible data become available.

For your copy, send the coupon and check or money order for $10.00. If you are located in Pennsylvania, add 35¢ for state sales tax.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EF07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:

1. Crucible HY-Tuf Data Sheet ☐
2. Further information on titanium mill products ☐
3. Permanent Magnet Handbook (Enclose check or money order) ☐

Name_____
Title_____
Company_____
Street_____
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

Circle 441 on Page 19

B.F.Goodrich

Lawn Boy cuts cost of fuel tank assembly with B. F. Goodrich Rivnuts®

When Lawn Boy designed their current power mower models, they decided to *suspend* the fuel tank underneath the streamlined shroud. But in order to do this they needed specialized fasteners that would fit inside the tank and provide shock-proof, fuel-tight nutplates.

They found that B. F. Goodrich Rivnuts would do this job better and more economically than any other fastener. Here's how. After the tank is formed, two holes are punched in its top. One man takes only a few seconds to upset Rivnuts in these holes. Screws are then inserted through the shroud and into the Rivnuts, attaching the tank solidly.

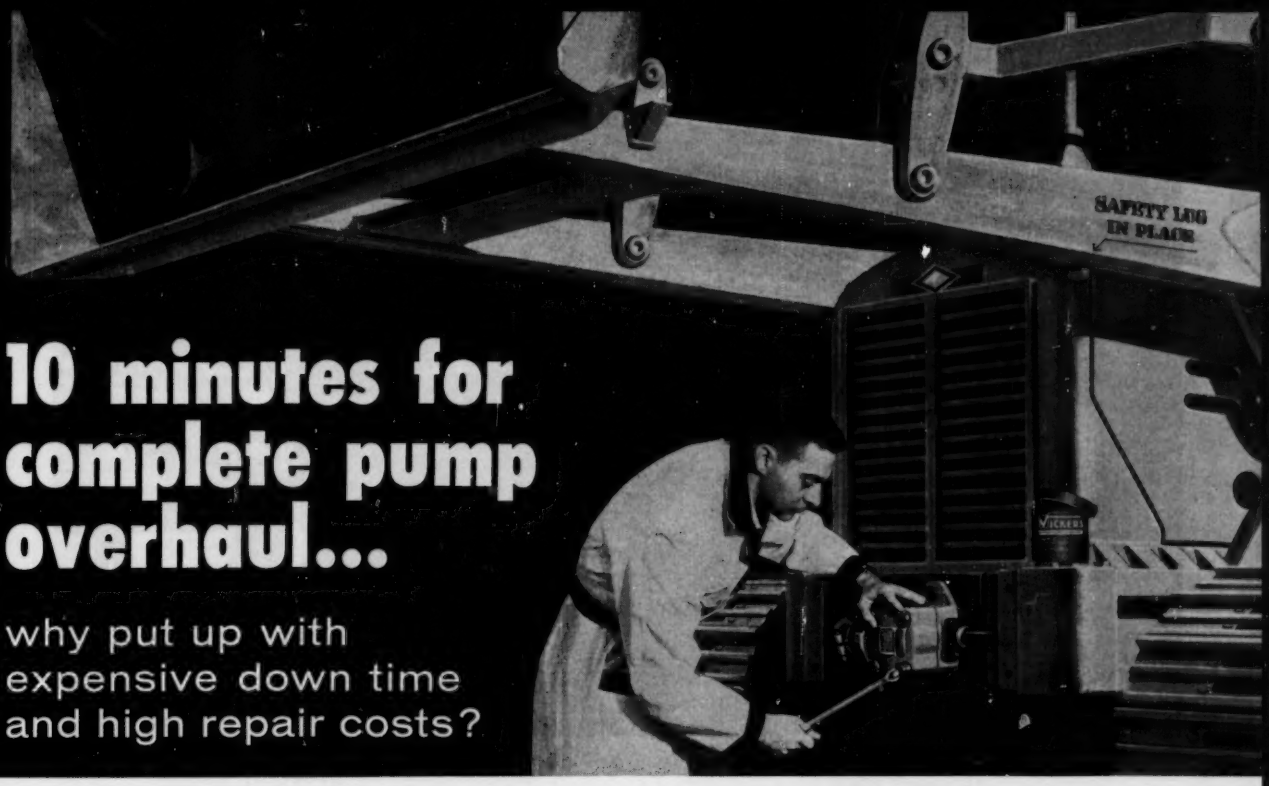
B.F.Goodrich Rivnuts provide firm nutplates that won't vibrate loose during operation of the mower. In addition, the special closed ends and tight clinching action of Rivnuts form a 100% fuel-tight seal.

Rivnuts can be used hundreds of ways to simplify production—give your products more eye-appeal, more sales-appeal! If you haven't already investigated their potential in your own business, why not do it now?

Send today for free Rivnut Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-69, Akron, Ohio.*

B.F.Goodrich ***aviation products***



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot maintenance with

VICKERS®

"High Performance" Pumps*
keeps your jobs on schedule
*PATS. & PATS. PENDING

Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

2 min

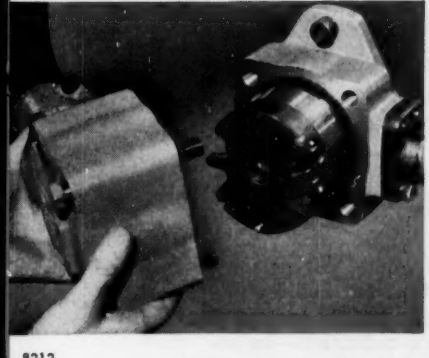
1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.

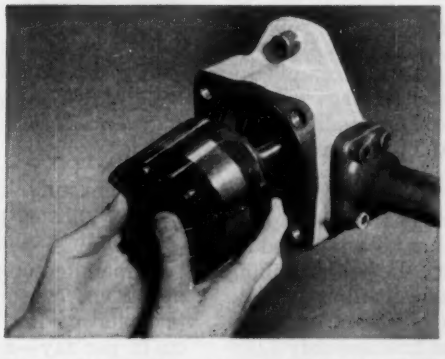
5 min

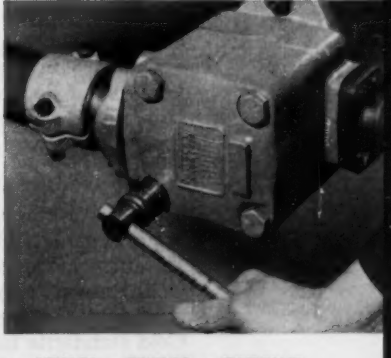
2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.

10 min

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.







8212

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 443 on Page 19

In the automotive industry alone, there are 30 Cold Bonderite installations.

How Cold Bonderite System cuts costs

Some actual user-experiences of savings in heat requirements, maintenance, water and electricity, and equipment after installing Cold Bonderite System.

Less than two years ago, the first public announcement of Parker's Cold Bonderite System was made.

Now, well over a hundred plants are using this revolutionary, money-saving system of phosphate-treating at low temperatures.

Some are among the country's largest plants, others are quite modest in size and production. Products treated range the list from automobile bodies to small appliance components.

From these users we have compiled a long list of documented savings records. In many cases, cost reductions have been greater than we had hoped to achieve.

The temperature tells the story! Cold Bonderite System solutions operate 60° to 75° cooler.

Heat Saved

The greatest percentage savings in heat requirements (90%) has been reported by an automotive plant. Before installing Cold Bonderite System, the finishing line used 50,000 pounds of steam an hour. Cold Bonderite in the line uses only 5,000 pounds per hour.

In another auto plant, heat savings are figured at 74% on a body line. A small parts finishing line in the same plant shows the same percentage reduction in heat requirements.

A manufacturer of metal cabinets reduced gas consumption for heating his phosphating line from 33,000 to 14,000 cu. ft. per day—a 56% reduction—by installing the Cold Bonderite System.

A famous maker of household equipment changed from conventional phos-

phating to Cold Bonderite System and saw his steam use plummet 66%.

Another manufacturer, an Eastern small appliance maker, reports that on gas expense alone he has cut his phosphating costs 45%.

Other Savings Pile Up

The magnitude of other savings, beyond heat consumption, has been surprising to users and very good news to their cost accounting departments.

Electricity, for instance. At the greatly reduced temperatures of the solutions, there is no need to operate exhaust fans. In one installation, the change to Cold Bonderite eliminated the need for replacing a $15,000 exhaust system.

Water use is reduced about 25% because there is less evaporation.

Maintenance costs nosedive with Cold Bonderite System in the finishing line. Lower temperatures in the heating coils mean less frequent—or no necessity for—cleaning the coils. When there is service to be performed, the maintenance crew can move right in without waiting for the installation to cool off.

Comparative 48-hour salt spray test proves performance. Left, untreated panel; right, panel Cold Bonderite-treated before painting.

One user figures that he has eliminated 364 manhours of maintenance time yearly with his Cold Bonderite System.

The same manufacturer has discovered, too, that the reduced temperatures have allowed him to eliminate a number of steam traps and steam coils costing over $8,000.

Coating Quality Is High

While Cold Bonderite System is saving money on the phosphating line in these many ways, there has been absolutely no diminution of quality in the coatings or their performance.

The Bonderite coating produced by low-temperature Cold Bonderite System matches the high standards set by Bonderite for thirty years. In salt spray, humidity and outdoor exposure tests, as well as in actual service on automobiles, appliances, furniture and many other products, performance has been proven.

Results are uniform hour after hour and day after day. Control and operation of the system is simple and practically foolproof.

Chemical Costs Held Low

All the savings attained by the use of Cold Bonderite System are *real* savings. They show up on the P & L statement because *chemical costs for this revolutionary development are not increased.* The special Bonderites and Parco Cleaners are strictly comparable to conventional hot treatments in the cost of treatment per square foot.

Only Parker Has Cold System

There is, actually, no other system like it. Cold Bonderite System was developed by Parker research, tested and perfected by Parker chemists. It has been proven over and over again as the way to get superior phosphate coatings on steel with spectacular savings.

The Parker representative in your territory is ready to advise and work with you to change your phosphating installation over to Cold Bonderite System. Call him in or write direct to Parker, Detroit.

**Bonderite, Bonderlube, Parco, Parco Lubrite – Reg. U.S. Pat. Off.*

PARKER RUST PROOF COMPANY

2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base | BONDERITE and BONDERLUBE aids in cold forming of metals | PARCO COMPOUND rust resistant | PARCO LUBRITE—wear resistant for friction surfaces | TROPICAL—heavy duty maintenance paints since 1883

1. Bronze Bearing, with self-adjusting "U" Cup Piston Rod Seal for longer wear.
2. Rod Wiper protects Piston Rod Seal and keeps Cylinder clean.
3. "U" Cup Seals expand with pressure to provide positive seal with minimum friction.
4. Wrench Flats make for easy installation.
5. Ground, hard chrome-plated Piston Rods have minimum yield strength of 125,000 psi.
6. Self-locking cushion adjusting screw and ball check are below surface for protection . . . easily accessible.
7. For extra strength, Cylinder Ends and Mounting Plates are machined from bar stock and steel forgings.
8. Cylinder is precision-finished brass for extra heavy duty.
9. Variety of mountings can be interchanged—easily match any installation requirement.
10. Interchangeable with all JIC Cylinders.

SCHRADER SQUARE-END CYLINDERS

meet and exceed JIC specs . . . 250 psi air . . . 750 psi hydraulic!

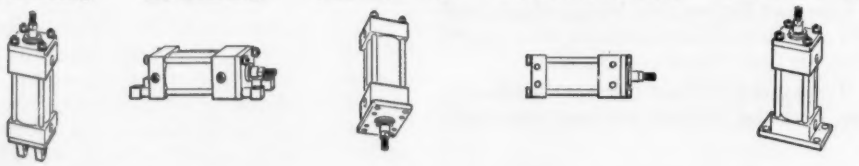
Here's compact, versatile straight-line power. Just look at the features!

Use Schrader's new square-end double-acting cylinders for holding, positioning, moving work—for push, pull or lifting—for automating manual operations. In five sizes up to 4-inch bore, and with five interchangeable mountings, these "square-ends" are economical and versatile. Bolt, leg, flush, side flush or base . . . each JIC Cylinder will mount all five ways. Suitable for air pressures to 250 psi, or hydraulically to 750 psi—available cushioned or non-cushioned.

You get safe, controlled, low-cost power with Schrader "square-ends"—another addition to the line of famous Schrader quality Air Control Products.

Complete stocks available locally—expert help to improve your air control hookups. Write for your complete specifications and data on these new "square-ends."

Bolt Mounting **Leg Mounting** **Flush Mounting** **Side-Flush Mounting** **Base Mounting**



Schrader®
a division of SCOVILL

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Division of Scovill Manufacturing Co.
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

Circle 445 on Page 19

Albany 1, N. Y.
Eastern Metals Warehouse, Inc.
ALbany 89-3281

Birmingham 5, Ala.
Allegheny Ludlum Steel Corp.
FAirfax 2-0548

Buffalo 7, N. Y.
Brace-Mueller-Huntley, Inc.
Victoria 8700

Cambridge 38, Mass.
Achorn Steel Company
UNiversity 4-8080

Charlotte 1, N. C.
Edgcomb Steel Company
FRanklin 5-3361

Chicago 32, Ill.
Allegheny Ludlum Steel Corp.
LAfayette 3-8650

Chicago 32, Ill.
U. S. Steel Supply Div.
BRunswick 8-2000

Cincinnati 1, Ohio
Allied Abrasives & Tools, Inc.
MUlberry 1-2222

Cleveland 3, Ohio
Allegheny Ludlum Steel Corp.
UTah 1-0500

Dallas 22, Texas
Peery Steel Company
FEderal 1-4354

Dayton 4, Ohio
Allegheny Ludlum Steel Corp.
BAldwin 2-8386

Denver 16, Colorado
Union Supply Co.
AMherst 6-2292

Detroit 20, Mich.
Allegheny Ludlum Steel Corp.
JOrdan 4-6900

Flint 1, Mich.
Hall Steel Co.
CEdar 4-6672

Grand Rapids 8, Mich.
Good Steel Service, Inc.
CHerry 1-4425

New York 17, N. Y.
Allegheny Ludlum Steel Corp.
MUrray Hill 2-0369

Philadelphia 34, Pa.
Edgcomb Steel Co.
GArfield 3-6300

Pittsburgh 30, Pa.
U. S. Steel Supply Div.
FAirfax 2-4200

Rochester 1, N. Y.
Brace-Mueller-Huntley, Inc.
COngress 6-6560

San Francisco 7, Calif.
Allegheny Ludlum Steel Corp.
GArfield 1-1804

Bridgeport & Shelton, Conn.
Trico Manufacturing Co.
DRexel 8-2633 & REgent 5-3306

St. Louis 8, Mo.
Allegheny Ludlum Steel Corp.
JEfferson 3-6700

Springfield 1, Mass.
Allegheny Ludlum Steel Corp.
REpublic 4-4996

Syracuse 1, N. Y.
Brace-Mueller-Huntley, Inc.
HOward 3-3341

Worcester 8, Mass.
Pratt and Inman
PLeasant 6-9592

York, Pa.
Edgcomb Steel Co.
47-1411

for warehouse service, technical help on tool steels

call Allegheny Ludlum

Hartford, Conn.
L. L. Ensworth & Son, Inc.
CHapel 9-7791

Houston 1, Texas
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MElrose 2-6521-2-3

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Los Angeles 22, Calif.
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RAymond 3-1181

Milwaukee 12, Wisc.
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WOodruff 4-3500

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Junger Steel & Supply Co.
WAlnut 7-8080

Warehouses stocking Allegheny Ludlum's Tool and Die Steels are located conveniently throughout the country. There's one near you. Jot down its phone number and call the next time you have a problem or need steel.

Allegheny Ludlum stocks a complete line of tool steel sizes and grades. Call your nearest A-L representative; you'll get quick service and counsel on such problems as heat treating, machining, grade selection, etc. Or write for A-L's publication list which gives full data on the more than 125 technical publications offered. They'll make your job easier.
ALLEGHENY LUDLUM STEEL CORPORATION, Oliver Building, Pittsburgh 22, Pa. Address Dept. MD-18.

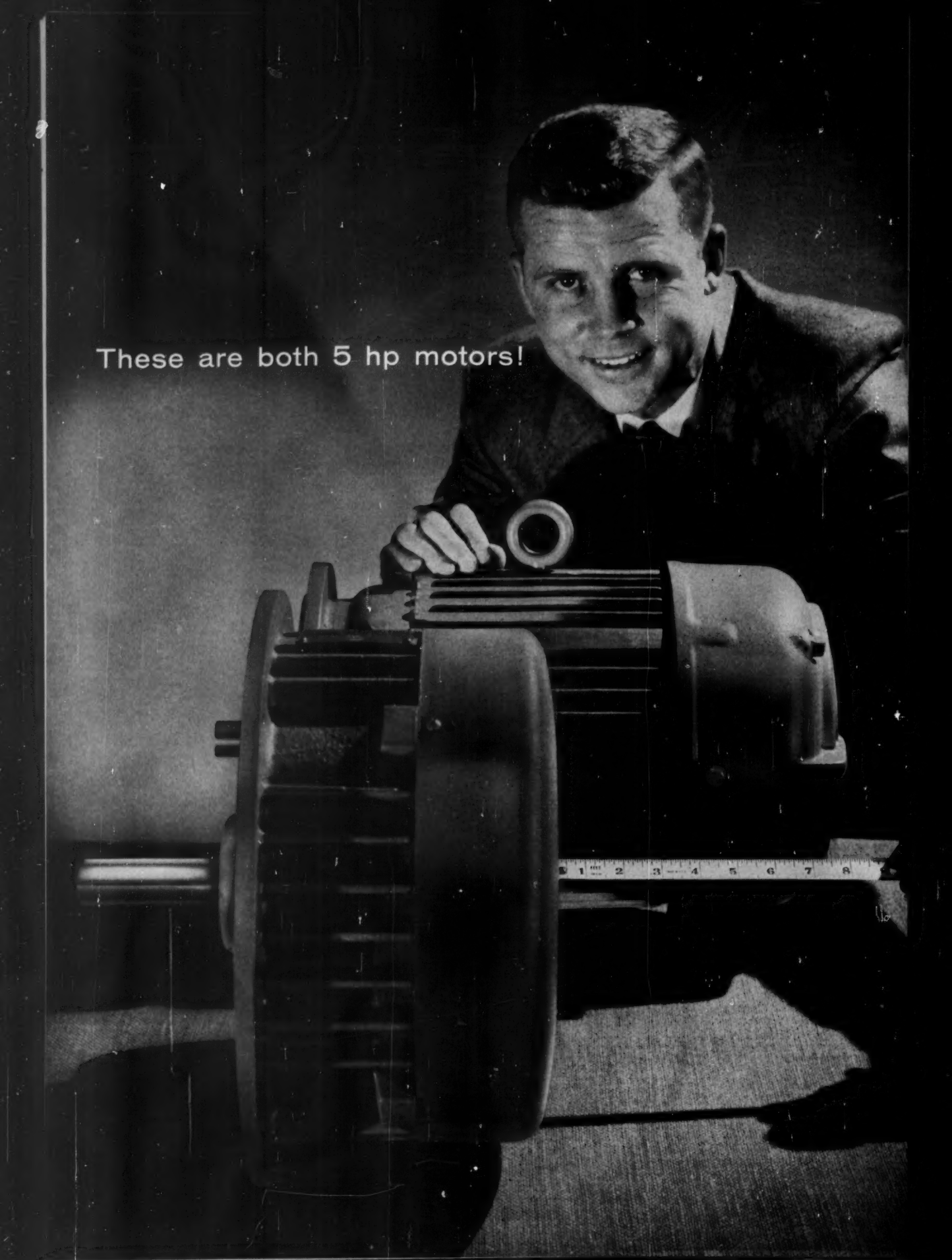
WSW 7265 (499)

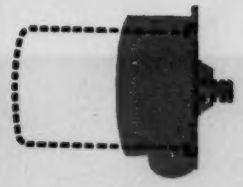
ALLEGHENY LUDLUM

Tool Steel warehouse stocks throughout the country... Check the yellow pages

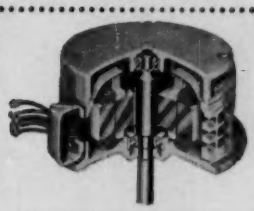
every grade of tool steel... every help in using it

Circle 446 on Page 19


These are both 5 hp motors!



SAME NEMA RATING IN
60% LESS SPACE



PERFORMANCE-PROVED RADIAL
AIR-GAP DEPENDABILITY

New-product news from Louis Allis

60% shorter—
but with radial air-gap design!

New Louis Allis Pancake Motor preserves all the advantages of conventional motor construction

The new Louis Allis Pancake Motor is your solution to trouble-free power in any space-cramped motor application.

The Pancake is a remarkably short flange-mounted motor — up to 60% shorter and 33% lighter than standard motors of the same rating! And it is built in *conventional* radial air-gap design!

It's done by an ingenious forming process which literally compresses the end coils of a conventional radial air-gap motor into an exceptionally short length. The result is a compact, light motor ideally suited for horizontal or vertical mounting on machine tools, roof ventilating fans, or *any* close-quarter installation where space is a critical design factor.

What's more, this is achieved without sacrificing a single desirable characteristic: the stator still contains the same iron and copper as standard Louis Allis motors . . . standard NEMA service factor is maintained . . . high insulative values are retained by using proved Louis Allis varnishes and new insulating techniques . . . over-sized pre-lubricated bearings are used to guarantee long bearing life . . . and the entire motor is enclosed in an industrial-type cast-iron housing designed to shrug off abuse!

The housing and flange are cast in one piece: this permits extra-accurate internal machining which extends bearing life and reduces noise levels to a new low.

Investigate the Pancake Motor through your local Louis Allis District office. Sized from 1 to 15 hp, at 1800, 1200, and 900 rpm, in open drip-proof and enclosed non-ventilated or fan-cooled enclosures. Write for Bulletins 2100 and 2150 to the Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wisconsin.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

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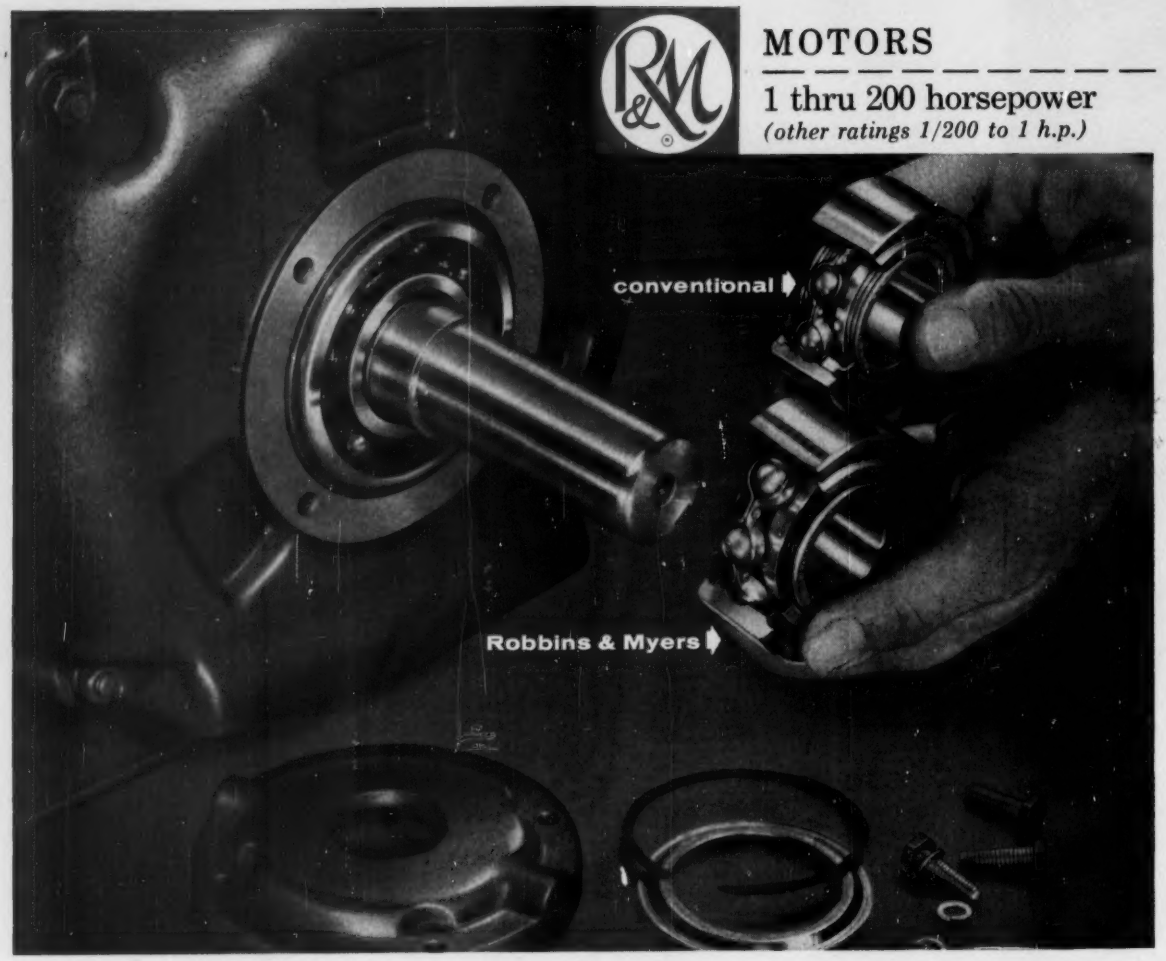
SM-104

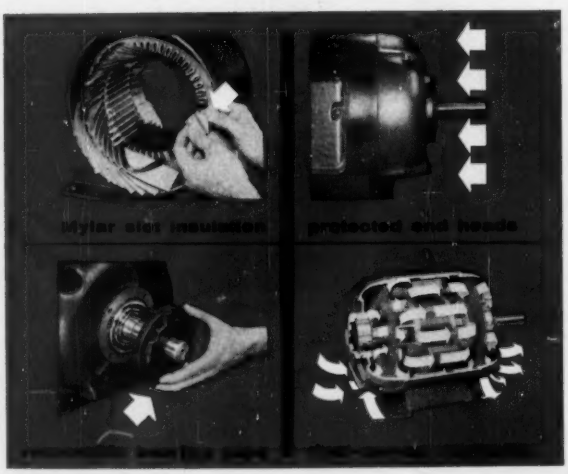


Double Width Bearings Hold More Grease...*Insure Longer Motor Life!*

Bearings in ROBBINS & MYERS motors run in double-width races with extra-large lubricant reservoirs. Bearings are fully sealed and pre-lubricated with laboratory tested grease which resists dust, temperature, humidity and high operating speeds. Tests prove these bearings can withstand six to nine years of severe service without relubrication. Bearings are further protected by metal seals on each side. Seals keep impurities out, prevent failure caused by "forgotten" lubrication or damaging over-lubrication.

R&M insures longer motor life with many additional features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling. For details, write today for Bulletin 520 MD

**DuPont registered trademark*

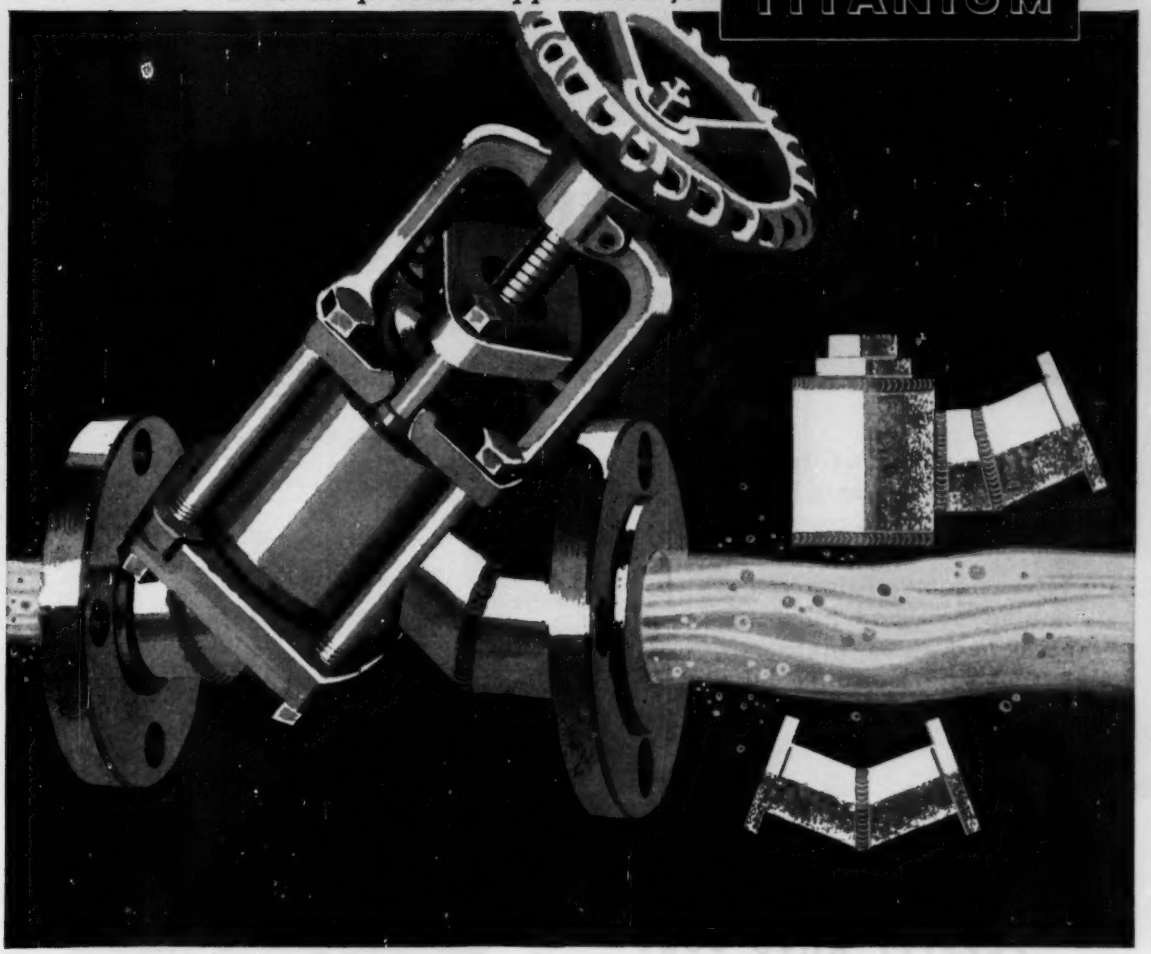


ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

Another practical application for **TITANIUM**



"CORROSION SPECIALISTS" TURN TO TITANIUM

...for working parts of new DURCO® valves

The Duriron Company, Inc., manufacturer of "Durco" valves and pumps, specializes in design and manufacture of equipment for corrosive service. Now they're among the first to turn to titanium ... producing, to order, fabricated valves used in highly corrosive applications. These valves are specially designed for handling hot nitric acid, hot chlorides, organic acids, mixed acids, etc.

In the Durco Type K "Y" valve, shown above, *all metal parts in contact with corrosive solutions are Mallory-Sharon titanium.* Mallory-Sharon engineers worked closely with Duriron designers on welding and forming techniques for the new valves. Mallory-Sharon titanium mill products are also being used in a Durco plug valve and a new line of corrosion resistant "Durcopumps".

For help in applying titanium's unusual corrosion resistant properties to *your* processing equipment, write for Technical Data Sheet on *Titanium Valves for Chemical Service.* Please address: Commercial Market Development, Department B, Mallory-Sharon Metals Corporation, Niles, Ohio.

MALLORY MS SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium · Zirconium · Special Metals

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DODGE PILLOW BLOCKS

WITH TIMKEN BEARINGS

America's super-quality line—with a 35 year record of keeping performance *up* and costs *down!* Five types—to fit practically any service condition. All assembled, adjusted, lubricated and *sealed* at the factory for precision performance—long life—dependability.

SPECIAL DUTY TYPE →

- Designed for extreme precision and high load capacities.
- Fully self-aligning.
- Special Duplex Timken Roller Bearing with tapered bore.
- Split tapered sleeve with straight cylindrical bore extends through entire length of housing.
- Easy to mount or demount. Adapter nut (or collar) clamps adapter sleeve to shaft with extreme firmness.
- Automotive type piston ring seals. Bearing is sealed both on and off the shaft.
- Rugged semisteel outer housing.
- Elongated bolt holes provide for lateral adjustment.
- Special dust cap protects lubrication fitting.
- Shaft sizes 1¼" to 8". Ask your local Dodge Distributor—or write us for Bulletin A670 giving complete technical data on America's most complete line of mounted bearings.

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.

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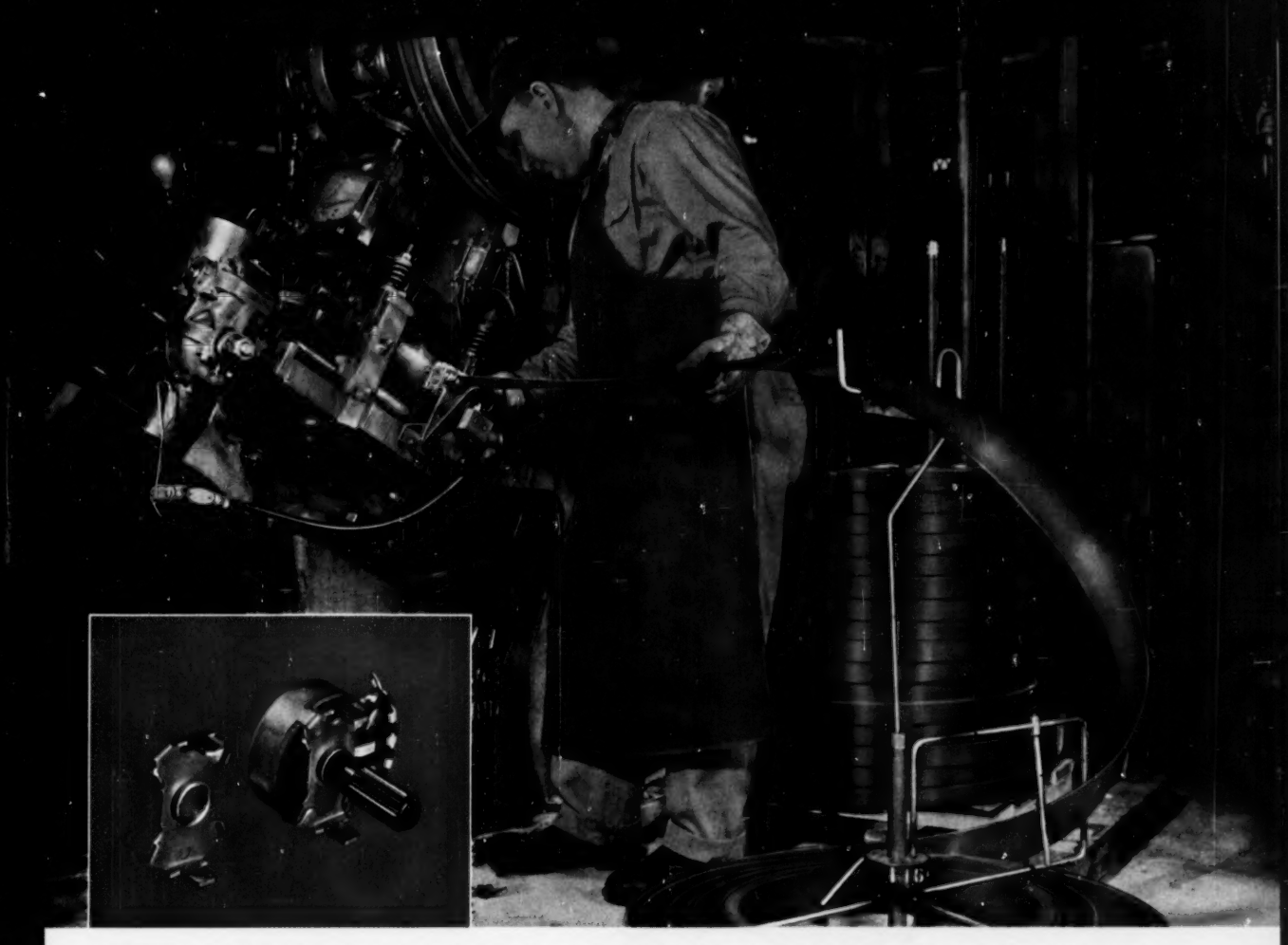
Circle 451 on Page 19→



COPPER-COATED Thomas Strip coils, 1½" wide, are made into the intricate television control part shown in the inset.

Thomas Strip Is Cost-saver at TV Parts Plant

For 20 years, copper-coated Thomas Strip steel was known at Chicago Telephone Supply Corp.'s Elkhart, Ind., plant as the metal to conquer a metal-working plague—scalloping during deep draws.

Now the precision-rolled product of Pittsburgh Steel Co.'s Thomas Strip Division has new claims to fame. It makes possible a one-piece, extruded and stamped mounting plate used to assemble and connect the variable resistor to the television set chassis.

Previously, Chicago Telephone made the grounding plate and mounting bushing in two pieces. The bushing being a relatively expensive brass mounting device, Thomas' copper-coated makes it possible to blank out the intricate part, punch a hole in its center and then extrude the edge of the hole into a load-bearing neck. All this is done at high production speeds with progressive blank and form dies.

In many applications at Chicago Telephone, similar severe demands are imposed. Examples:

▶ **THICKNESS TOLERANCE**—As tight as ±.0005". A variation of ±.001" can cause a potentiometer cover to be off .005".

▶ **UNIFORM TEMPER**—Some parts are made at speeds up to 400 units per minute. Any wide hardness deviation results in troublesome forming variations.

▶ **SHEARABILITY**—Punched and blanked parts have tolerances so snug that the slightest burr prevents proper assembly.

▶ **UNIFORM COPPER COATING**—Copper acts as a necessary die lubricant and a base for nickel plating. When the mounting plate was made from plain steel, die life ranged from 40,000 to 62,000 units. Now, with the more difficult mounting plate, die life averages 250,000 units between regrindings.

Whether you need dimensional accuracy, surface, temper, aid to die life, chemistry or design and production advantages, you'll find them in Thomas Strip. It is a controlled rolled steel, plain or in a variety of electrolytic coatings of copper, brass, nickel, zinc, tin, chrome and lacquer with a full range of tempers, widths and finishes. Thomas Strip also is available with an attractive but durable pattern rolled right into its surface. For details, contact any sales office. Do it today.

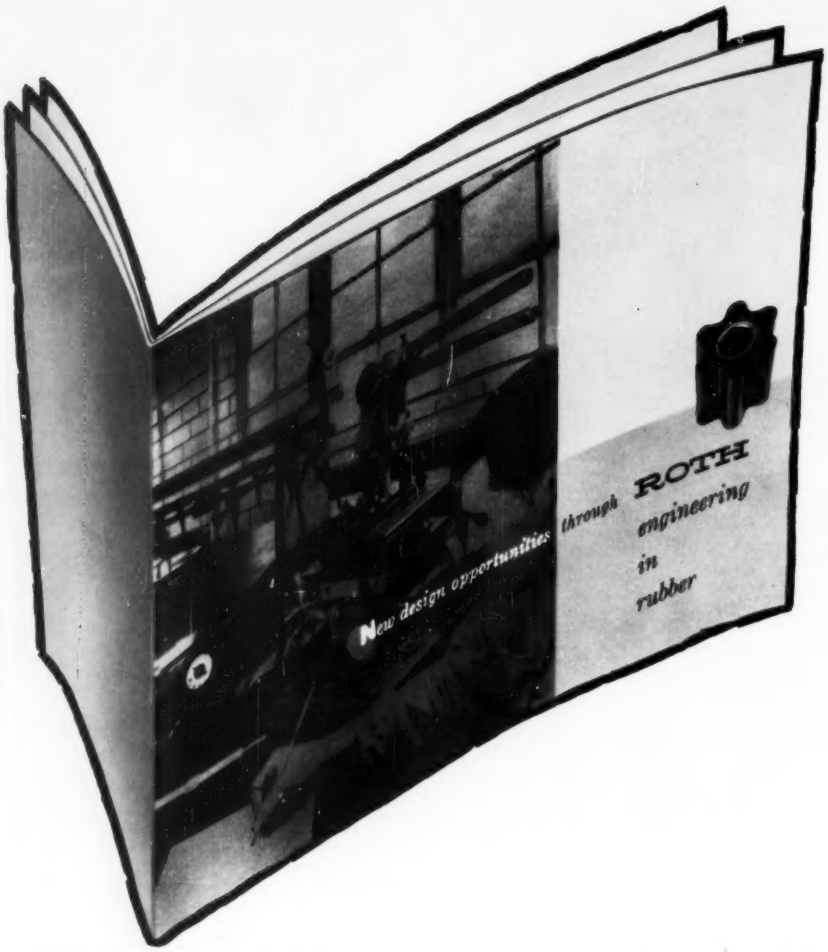
Thomas Strip® Division

Pittsburgh Steel Company

Grant Building · Pittsburgh 30, Pennsylvania

District Sales Offices:

Atlanta	Detroit	Philadelphia
Chicago	Houston	Pittsburgh
Cleveland	Los Angeles	Tulsa
Dayton	New York	Warren, Ohio



See how "Custom Rubber" solves product problems!

Need a better material for a problem product? Want to cut costs? Boost service life? Here's a new booklet with some eye-opening facts about molded rubber . . . *custom-formulated* by Roth.

At Roth you will find the specialized research facilities and engineering skills needed to create special rubber for specific applications. You will also find advanced molding techniques and modern manufacturing facilities, required for precision production of molded parts, speedy, economical handling of large or small runs. More important—at Roth you will always encounter wholehearted, conscientious interest in your problems.

Send for this authoritative new booklet. See idea-suggesting uses of custom rubber . . . see how Roth Rubber Specialists can help you find answers to material selection problems. Ask today for your copy of "New Design Opportunities through Roth Engineering-in-Rubber."

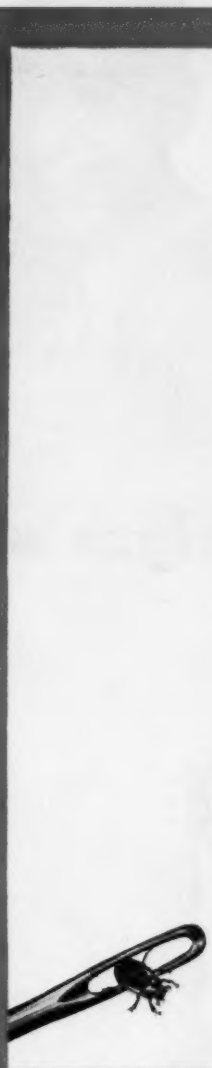
ROTH

RUBBER COMPANY

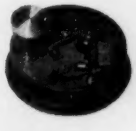
1860 S. 54th Ave., Chicago 50, Ill., BIshop 2-1060

Division of Vapor Heating Corporation

Circle 452 on Page 19



Smallest of the Small. A pigmy beetle could easily crawl through the eye of an ordinary sewing needle, as shown by this equally magnified view of both. Among the tiniest of insects, some species of pigmy beetles reach about one-hundredth of an inch in length.



Miniature for Missiles. This tape recorder, shown one-sixth actual size, is a vital unit in the communications system of the Army's "talking satellite." Constant low-torque and quiet operation of MPB bearings in it maintain accurate tape position.

Man with Miracles. Like all MPB Sales Engineers, Dean Skillin makes a practice of showing people how small, precision-made MPB bearings reduce maintenance, increase economy, and solve miniaturization problems. He's ready to do the same for you.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN TAPE RECORDER SHOWN ABOVE

Little Things That Count. There's nothing new, in the larger sense, about ball bearings. But miniaturization of these familiar components is a wholly modern development. Forty years ago, for example, MPB was first to manufacture bearings with O.D.'s as small as 3/8", and with precision that brought new aid to science and industry. Today, after continual pioneering in miniaturization, MPB produces over 500 types and sizes of bearings, ranging down to 1/10" O.D., with specials as required. Our catalog brings you details on these bearings. Write for it, or for engineering advice, to **Miniature Precision Bearings, Inc.**, 106 Precision Park, Keene, N.H.

MINIATURE PRECISION

MPB

BEARINGS, INC.

Helps you perform miracles in miniaturization

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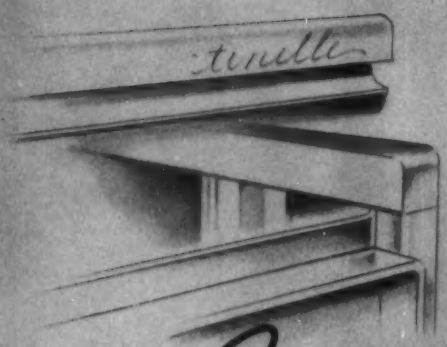
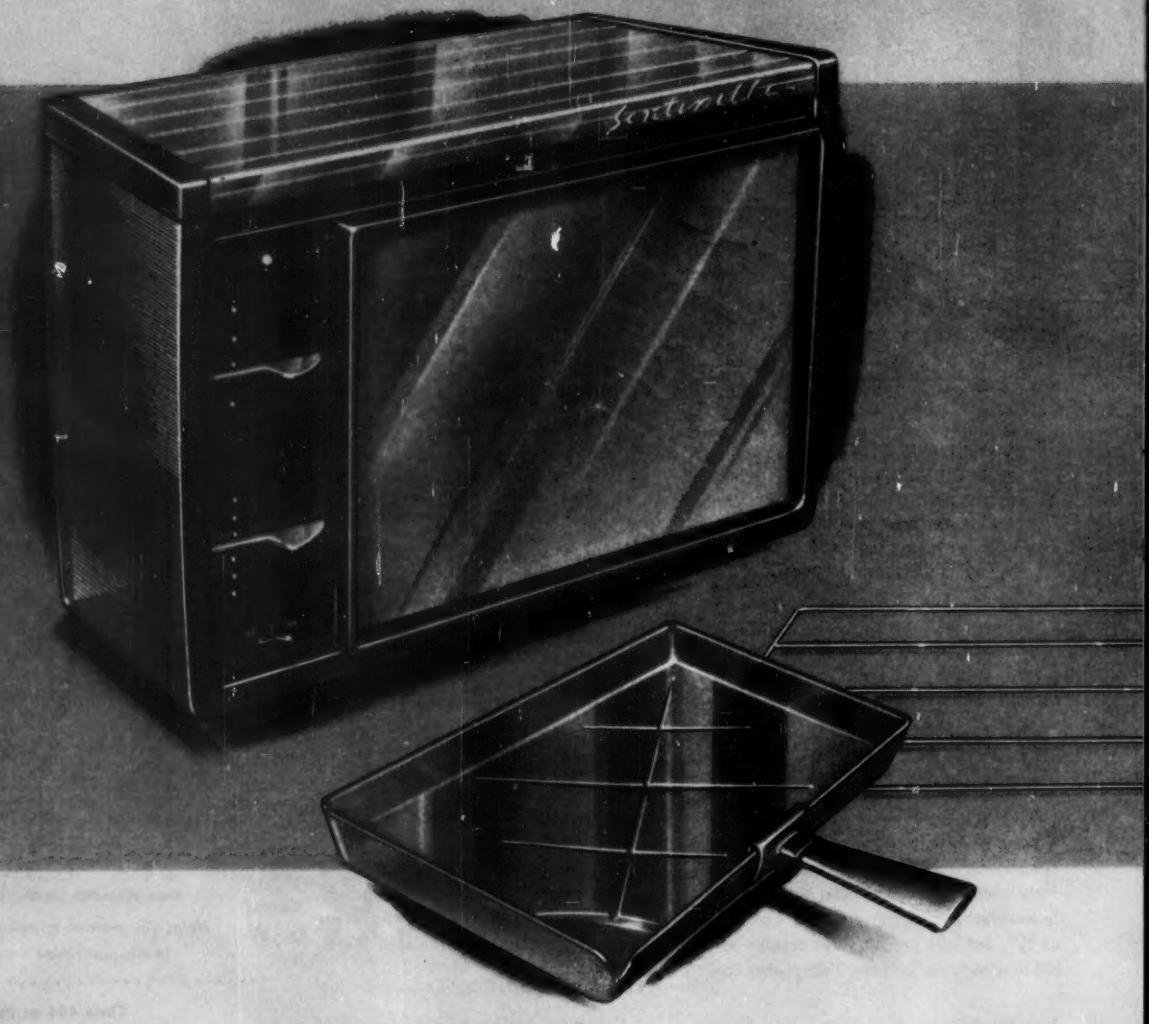
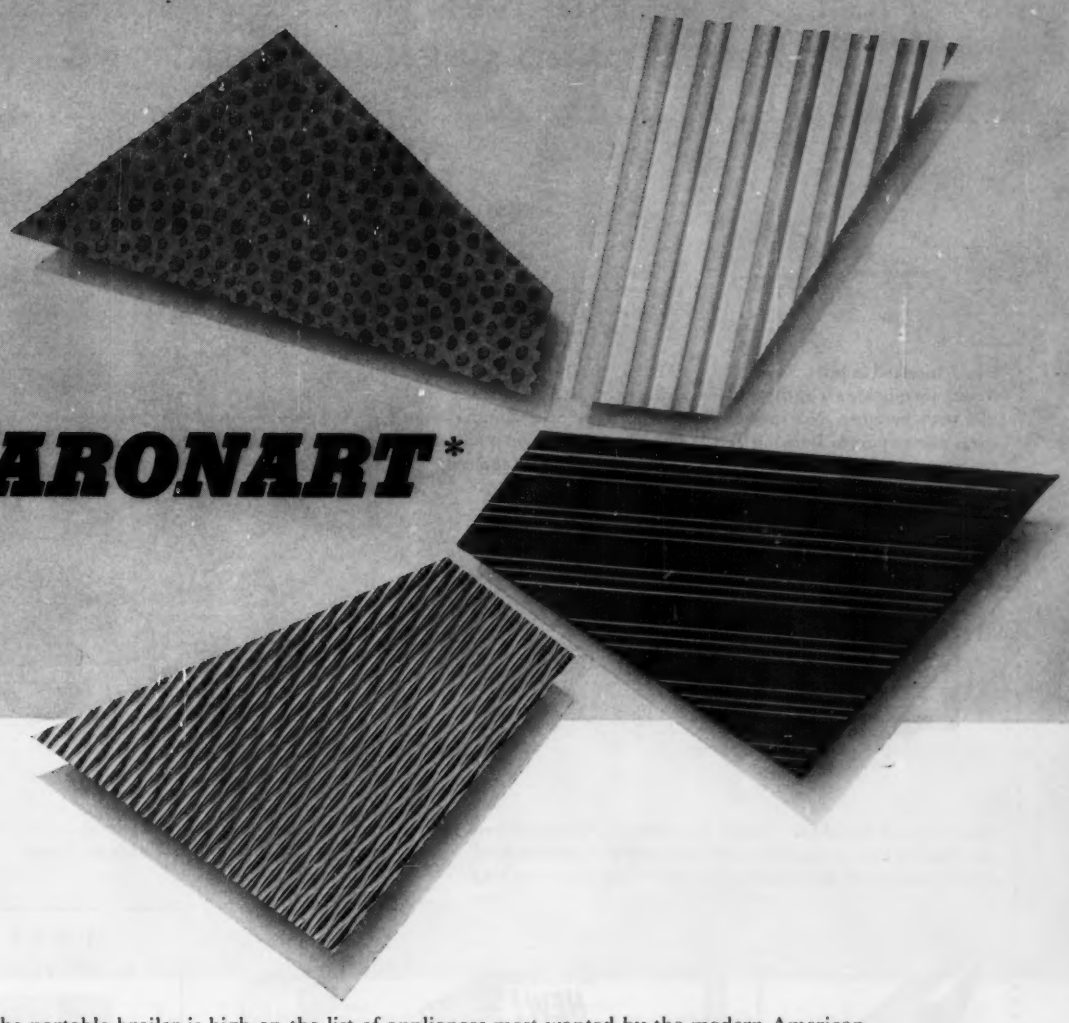


One of America's best known and most successful designers, Russel Wright, is practically a household word to Mrs. America. He, more than any other one man, has brought practical design to the average American housewife. Mr. Wright believes "good design" should be universal and his general aim is to create the widest variety of products for the widest possible market at the lowest possible cost so that "good design" can reach everyone.

Russel Wright designs with..





...SHARONART*

The portable broiler is high on the list of appliances most wanted by the modern American housewife. Until recently, little attention was paid to its design. The unwieldy bulk and lackluster styling of most models contrasted with the functional beauty of today's colorful kitchens and kitchen tools.

Russel Wright, world famed designer, has applied his talents to this appliance and has created a broiler with the attractive tailored look designed to harmonize with modern day kitchens.

In place of the outmoded polished chromium cover, Mr. Wright has utilized Sharon Steel's exciting new Sharonart* stainless in combination with a main shell of colored baked enamel over textured Sharonart*. Russel Wright has replaced impractical broiler operation with simple, functional, press-down levers that automatically set the thermostat and timer, and has included a stainless steel well-and-tree tray designed to be carried to the dining table and generous bakelite handles for safe carrying of the unit.

Whether you make broilers—or any other appliance—it's certain Sharonart* will give your product the same fresh look Russel Wright has achieved in this broiler design. *The Sharon Steel Corporation, Sharon, Pa.*

*T. M.

SHARONSTEEL

SHARON *Quality* STEEL

FAST, HAMMER-DRIVEN RIVET ECONOMICAL FOR BLIND AND OPEN APPLICATIONS

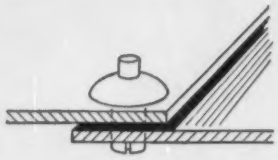


Fig. 1 Inserted in hole, Southco Rivets are quickly set by driving pin with hammer. No special tools are required. Bucking is not necessary.

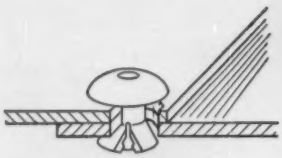


Fig. 2 Expanded prongs force sheets or parts together, hold them tightly in compression. No metal is removed, no grinding or finishing is required.

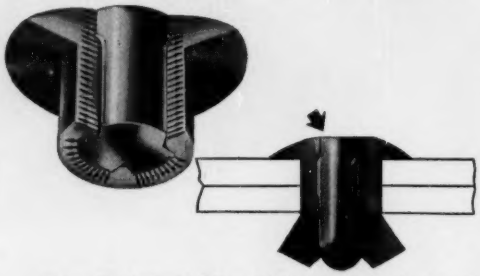


Fig. 3 Pin is locked securely into rivet by displaced metal filling unique grooves. Compression forces are utilized for greater strength.

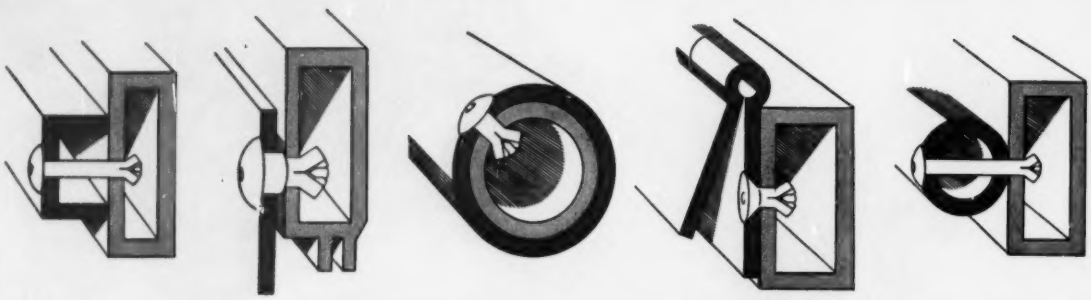


Fig. 4 Ideally suited for "blind" applications, Southco Rivets are worked by one man from one side only and require minimum space inside closed area. They eliminate costly bucking arrangement or time-consuming finishing. Supplied as a unit, they require no job time for assembly or fitting.

Fig. 5 Access or open fastening utilizes the simplicity, speed and vibration-resistance of Southco Rivets.

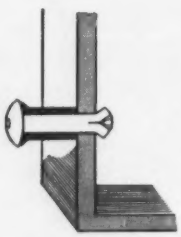


Fig. 6 Ferrules are used as spacers for numerous applications. Here the Southco Rivet forms a drawer pull in conjunction with a flanged tube.

Fig. 7 Increased head size distributes holding pressure over larger area, permits higher loading on wood, plastics and similar materials.

Fig. 8 A blind head can be formed inside the wood. This application is particularly useful when it is desirable to have one surface of the wood unmarred.

FREE

RIVET FOLDER

Send for your free copy of "Southco Drive Rivets" Folder. Gives complete information on the application, installation, and specifications of aluminum and steel Drive Rivets.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

SOUTHCO FASTENERS

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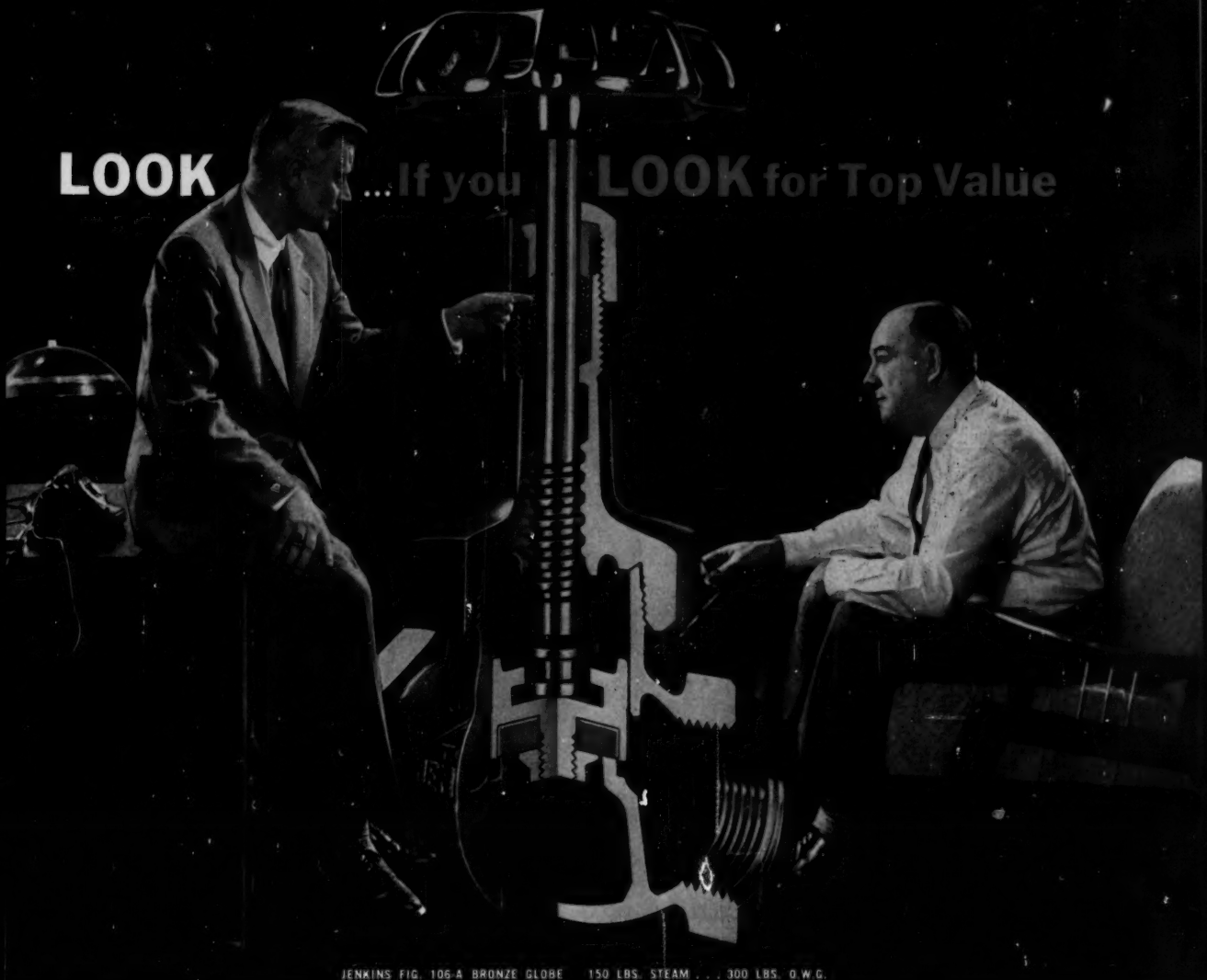
LION



JENKINS FIG. 106-A BRONZE GLOBE 150 LBS. STEAM . . . 300 LBS. O.W.G.

in Disc Equipped Bronze Valves

LOOK at that Wheel — Tough malleable iron. Design unequalled for cool, sure grip.

LOOK at the Index Plate — Has Fig. No. etched in green background. Held by wheel nut which is secured by rolled-over spindle end.

LOOK at that Spindle — Made of high tensile bronze. See how much heavier it is . . . how many more deeply cut threads engage bonnet. And, the crowned head that reduces friction on disc holder. Sure, it costs more to make a spindle this way. But it reduces wear, preserves packing, means easier operation.

LOOK at the Packing Nut and Gland—Note the heavy and deep bronze hex. And, that bronze gland designed to compress packing toward spindle.

LOOK at that Packing Box — Its depth equals 1½ times spindle diameter. More packing space means less repacking. An asbestos, lubricated and graphited packing is used.

LOOK at that Bonnet — One-piece, screw-over design with big hex surfaces is easy to remove. Take an extra look at the bevel joint between bonnet and body, serving as an internal brace against the crushing effect of the bonnet assembly. Millions of Fig. 106-A in use for years prove this unique design licks distortion and springing.

LOOK at the Disc Holder — It's the Slip-on Stay-on type originated by Jenkins. Correct protective depth prevents flaking or cracking of disc.

LOOK at the Disc — Easily renewed without removing valve from line. Made of compositions to suit various services . . . and **made by Jenkins,** the only maker of both valves and discs.

LOOK at that Body — Just compare wall thickness of this high tensile bronze body with any other valve. The factor of safety is many times higher than rating requires. See the curved diaphragm to protect seat from distortion by pipe strain. Note that the raised seat is higher to permit more reseating operations . . . and wider, so it won't cut into disc. Pipe threads are full length and clean cut.

LOOK at this . . . for Throttling

—Just replace the standard disc nut with this Throttling Nut and a Fig. 106-A becomes well-suited to throttling service. This unique nut reduces the effects of wire drawing and its long legs restrict flow for accurate control. Many plants take advantage of this versatile valve to reduce valve and parts inventory.

THE FIRST renewable composition disc valve was a Jenkins Valve, originated nearly a century ago. Compare today's Fig. 106-A Bronze Globe with any other. See why so many valve users agree that a *Jenkins* is still the FIRST for top value. For descriptive folder No. 189-B on the full line of Jenkins Bronze Globe, Angle and Check Valves write to Jenkins Bros., 100 Park Avenue, New York 17.

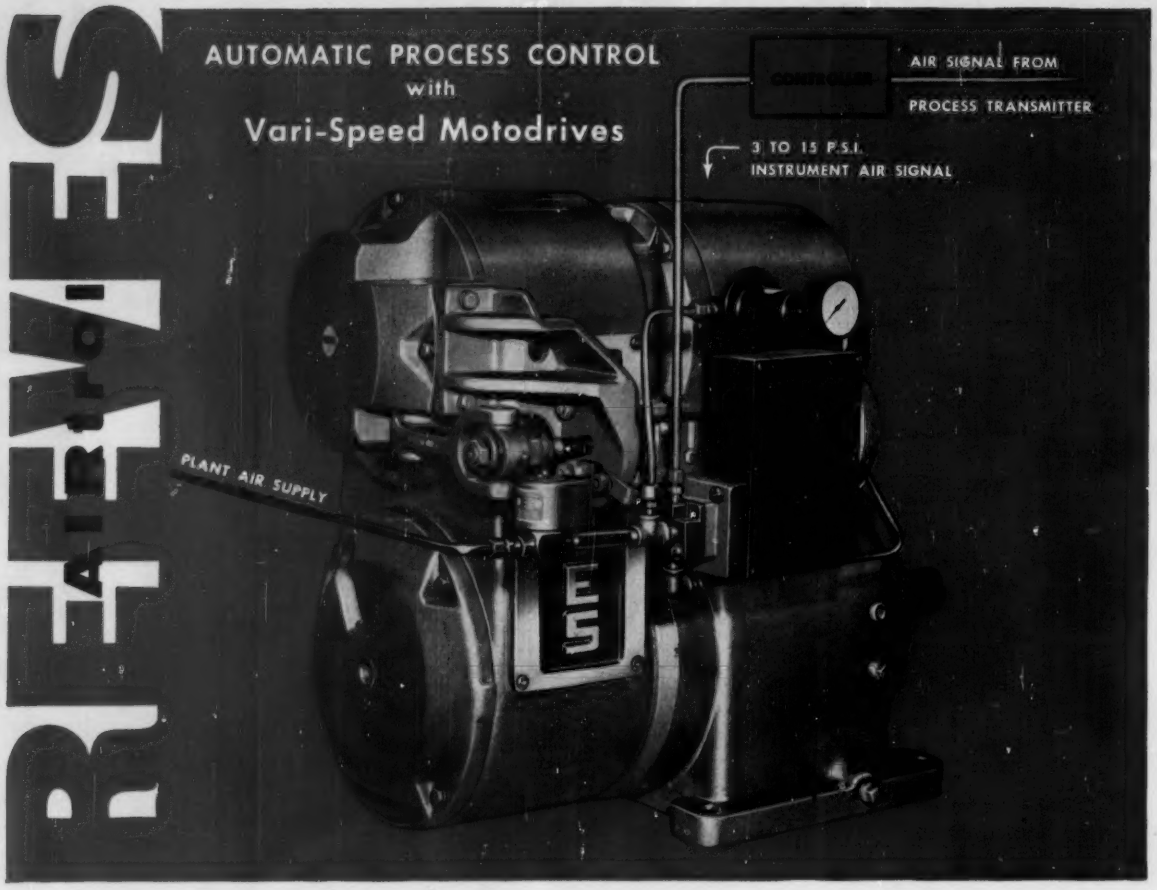
Circle 456 on Page 19

SOLD THROUGH LEADING DISTRIBUTORS EVERYWHERE

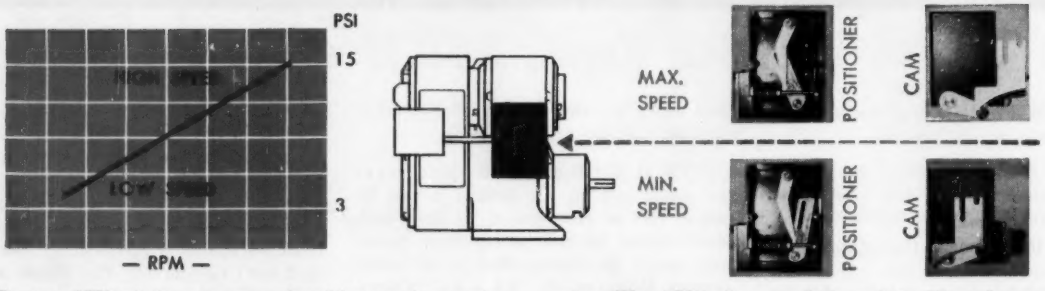
JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

JENKINS SINCE 1864



Sensitive Speed Reaction to Controller Signals ... Straight Line Variable Speed Output



● REEVES AIRtrol, in an open or closed loop system, automatically and continuously corrects operating speeds to compensate for variations in materials or energy (i.e. temperature, liquid level, density or flow).

As the final control element, the pneumatically-controlled Motodrive assures sensitive and stable control throughout the speed range.

Linear speed output is a result of the exclusive cam design. The AIRtrol responds to a 3 to 15 p.s.i. pneumatic signal, and is adaptable to all standard process instrumentation.

The AIRtrol is available on all REEVES Motodrives . . . hundreds of assemblies from ¼ through 40 hp., 2:1 through 10:1 speed range, and 1.7 through 4660 rpm.

For examples of AIRtrol in process control systems, write Dept. H39a for AIRtrol Instrumentation Data Sheets.

VARI-SPEED MOTODRIVE
VARI-SPEED MOTOR PULLEY
VARIABLE SPEED TRANSMISSION

REEVES PULLEY COMPANY
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REEVES

Circle 457 on Page 19

SUPER DYLAN polyethylene gets to the heart of tough design problems

Light-duty wheels—where a tough, rust-proof, light-weight, easily moldable material is needed—SUPER DYLAN.

Putty knife and paint brush handles—where a low cost, durable material, to which paint will not stick, is called for—SUPER DYLAN.

Auto heater and defroster outlet—where a material must remain dimensionally stable under heat without losing its strength or rigidity—SUPER DYLAN.

Scripto Pen cartridges—where outstanding environmental crack-resistance is a must; clear enough to see the ink supply—SUPER DYLAN.

Roller skates—where a moldable, colorful material with built-in self-lubricating properties to combat friction is called for—SUPER DYLAN.

If you're designing a product that demands a hard-working, chemically-resistant plastic that is strong, easily colored, possesses a glossy finish and is simply processed—SUPER DYLAN is your answer. For more information, write to Koppers Company, Inc., Plastics Division, Dept. MD-69, Pittsburgh 19, Pa.

DYLITE *expandable polystyrene*, DYLENE *polystyrene and* DYLAN *polyethylene are other fine plastics produced by Koppers Company.*

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KOPPERS

Circle 458 on Page 19

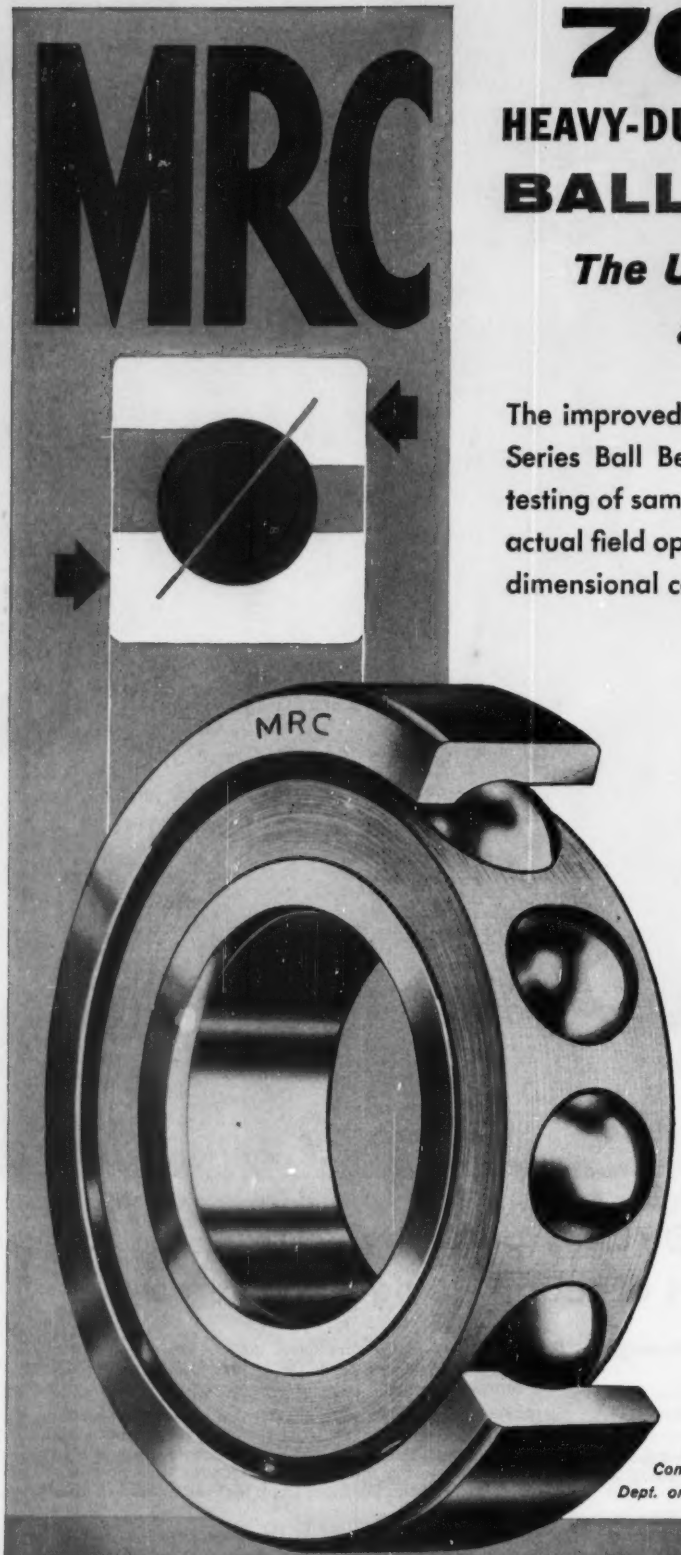
7000-P

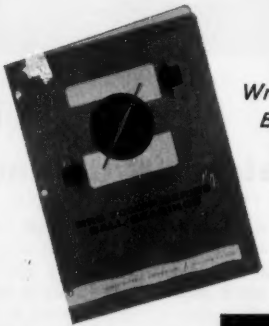
HEAVY-DUTY ANGULAR-CONTACT BALL BEARINGS

The Ultimate in Capacity and Reliability

The improved characteristics of the M-R-C 7000-P Series Ball Bearings are the result of controlled testing of sample or "Star Quality" bearings under actual field operating conditions. The best possible dimensional control, material, heat treatment and internal design were incorporated in these bearings. The results were so satisfactory that the stellar qualities of these test bearings have been incorporated in and become an integral part of the M-R-C 7000-P bearing.

Therefore, to obtain the advantages of "Star Quality" performance use M-R-C 7000-P bearings for your heavy duty requirements.





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Consult OUR Engineering Dept. on YOUR bearing problems

MRC BALL AND ROLLER *bearings*

MARLIN-ROCKWELL CORPORATION

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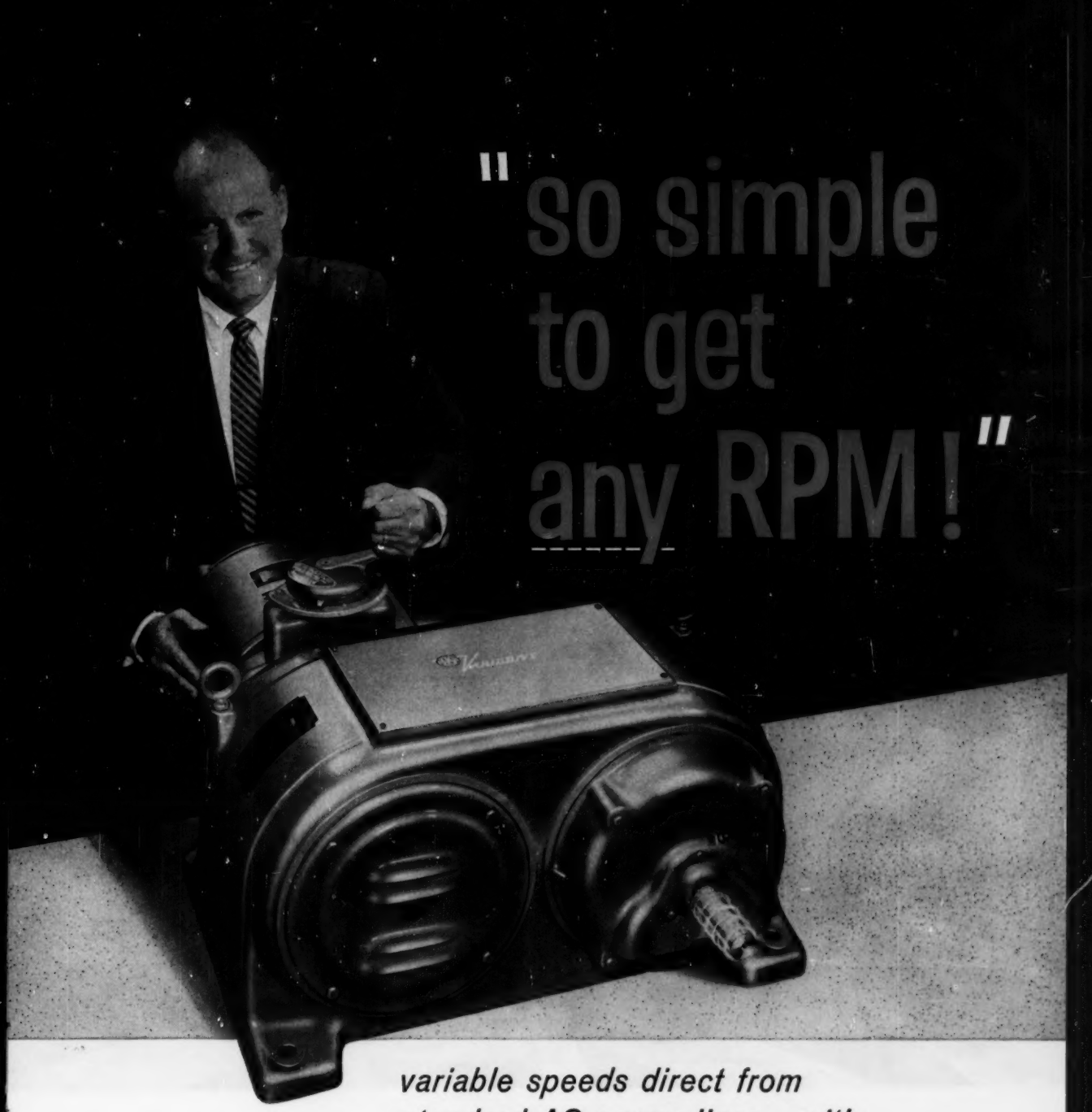

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U.S. VARIDRIVE MOTORS

Smooth, stepless speed changes to the split RPM—with the simple, completely self-contained U.S. VARIDRIVE MOTOR! Just plug into any standard AC power line.

Why bother with DC Converter, DC Generators, complicated electronic tubes and circuits that require special technicians? Why risk costly production shutdowns?

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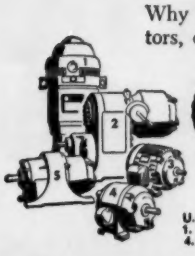

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FREE COLOR-ILLUSTRATED BROCHURE
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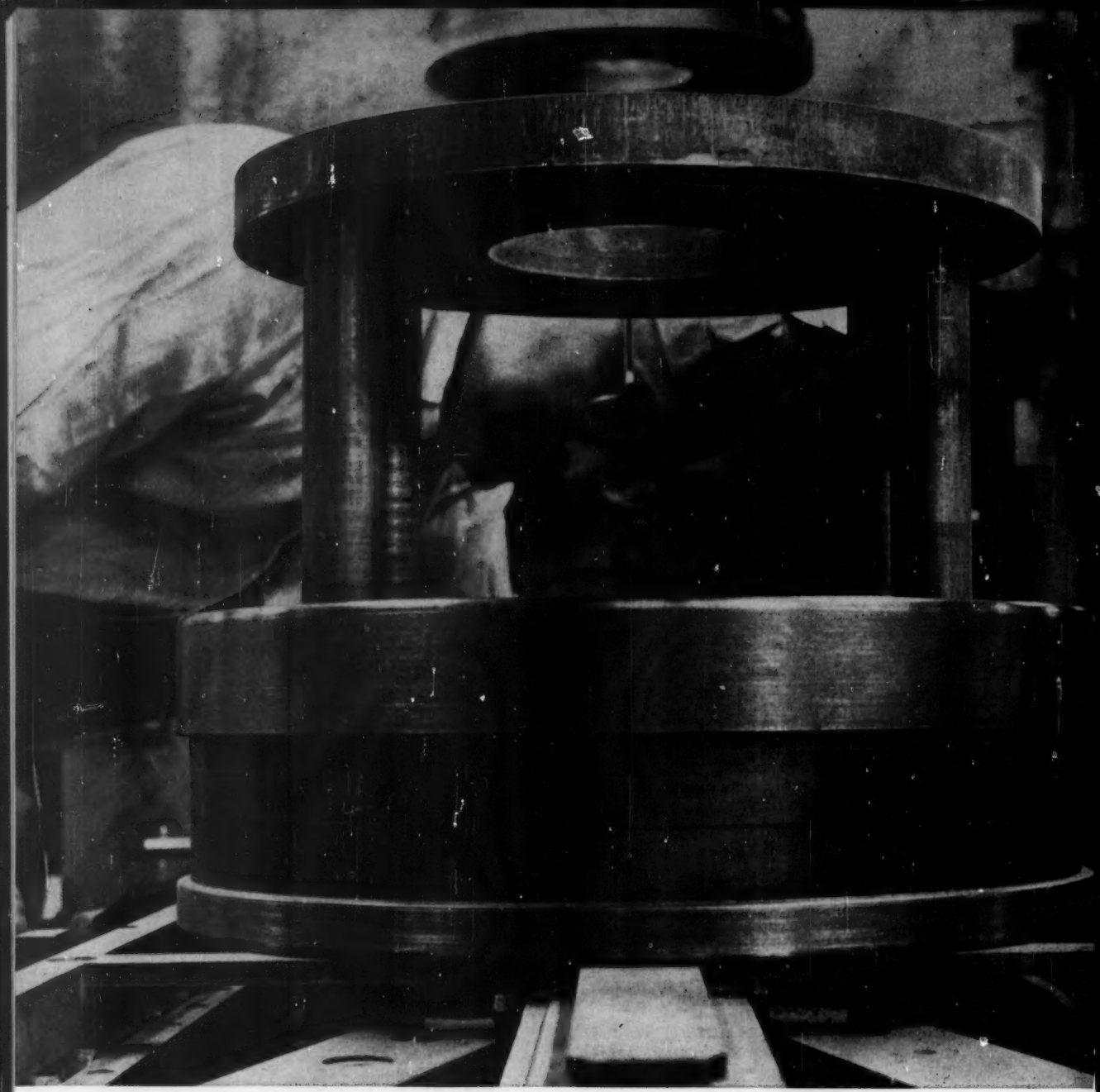

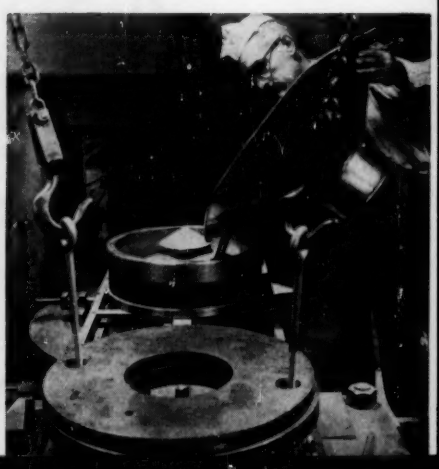

Here's a tough old squeezer that won't wear out

The donut-shaped steel disc in the main illustration is the mold plate used in a large hydraulic press. Under 2,000 tons of pressure, it squeezes an abrasive mixture in a mold to make grinding wheels. It's a tough job, and Waltham Grinding Wheel Company had to replace these discs every few months because they wore down and became unbalanced. Replacements were expensive and they wasted production time.

Finally, Waltham tried a plate made of USS "T-1" Steel. It has been used for more than a year now, and Waltham engineers say it will last indefinitely.

"T-1" constructional alloy steel has a minimum yield strength of 100,000 psi. It is exceptionally tough and resistant to abrasion—can be furnished heat treated to a minimum hardness of 321 Brinell. Compared to carbon steel, it has four times more resistance to atmospheric corrosion. In spite of its strength and toughness, "T-1" Steel can be formed, machined and welded. And because of its strength, it can be used in lighter gages, reducing weight as much as ⅔, depending on the application.

If you would like to have complete information about "T-1" Steel, write for our book "USS 'T-1' Steel," United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS

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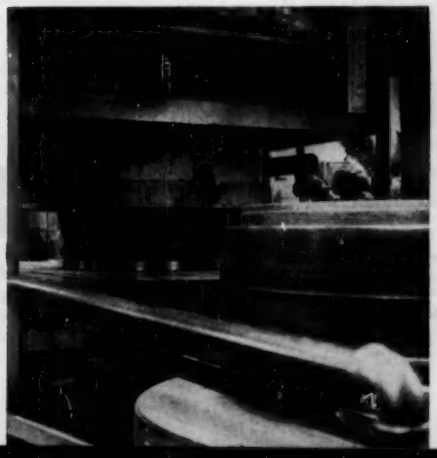
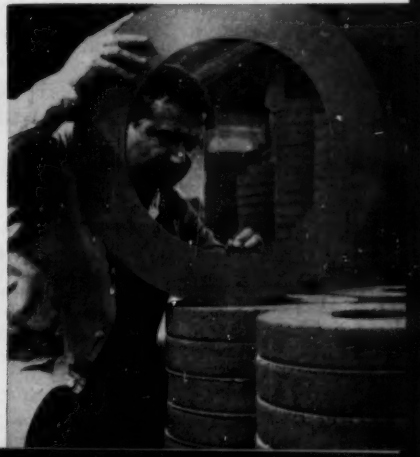
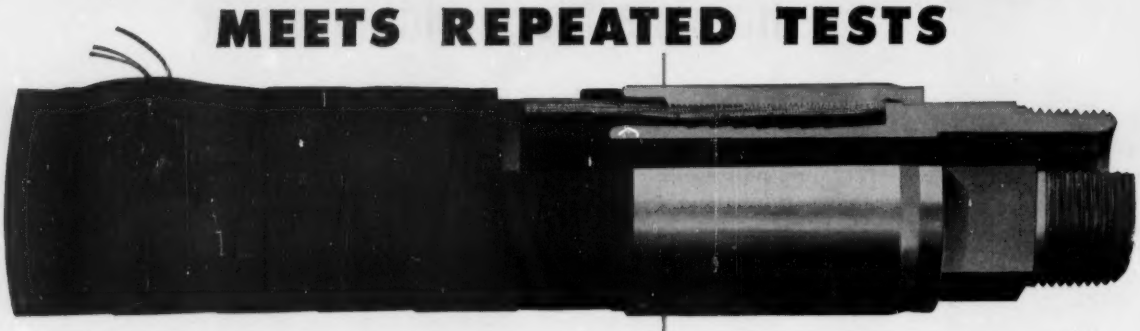
Please direct inquiries to advertiser, mentioning MACHINE DESIGN





Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

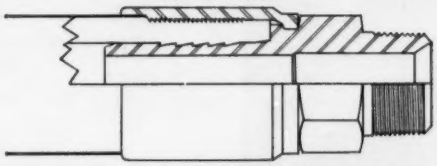
Increasing demand for greater power brought about the use of higher pressures in hydraulic systems. This not only calls for greater hose strength, but far more critical engineering in coupling design and application.

EASTMAN is contributing toward the development of the trend toward higher pressures—not only in the design and application of coupling to hose—but in the more exhaustive tests required to assure adequate safety under high pressure operations.

The actual photo above is typical of many tests in Eastman laboratories proving that the hose did not fail at the coupling—demonstrating that the coupling was designed and applied to form *a bond which was stronger than the hose itself.*

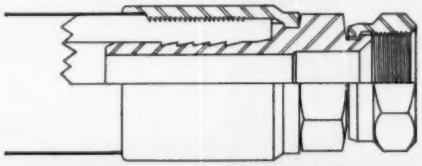
If you have an application requiring higher pressures, let our engineering department demonstrate the superiority and economy of Eastman applications, and quote on complete Hydraulic Hose Assemblies.

MALE NPTF



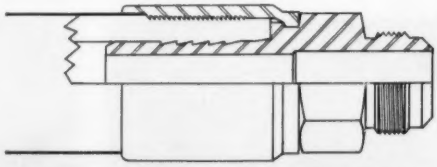
Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12M	¾	1 7/16	1 9/32	20,000	5,000
8416-16M	1	1 ¾	2 5/32	16,000	4,000
8420-20M	1 ¼	2	1 53/64	12,000	3,000
8424-24M	1 ½	2 ¼	1 21/64	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12FH	¾	1 7/16	1 9/32	20,000	5,000
8416-16FH	1	1 ¾	2 5/32	16,000	4,000
8420-20FH	1 ¼	2	1 53/64	12,000	3,000
8424-24FH	1 ½	2 ¼	1 21/64	10,000	2,500

MALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12MH	¾	1 7/16	1 9/32	20,000	5,000
8416-16MH	1	1 ¾	2 5/32	16,000	4,000
8420-20MH	1 ¼	2	1 53/64	12,000	3,000
8424-24MH	1 ½	2 ¼	1 21/64	10,000	2,500

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Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.

Technical Bulletin 200—High Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple Wire Braid Hose.

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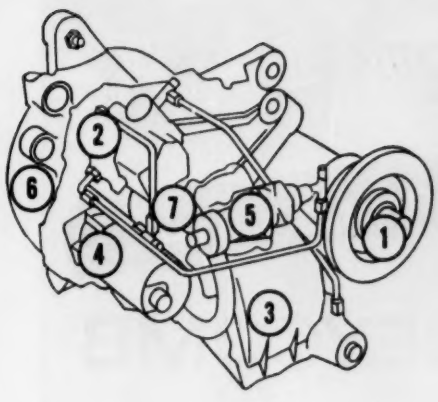


1 —INPUT SHAFT
Accepts varying input speeds from 3800-7000 RPM.

2 —GOVERNOR
Maintains ±0.25% steady state speed over 200° F temp. range, ±0.5% for 400° F temp. range and 0.5 second maximum full load transient recovery time.

3 —VARIABLE DISPLACEMENT PUMP/MOTOR
Either pump or motor, depending on whether it is adding to or subtracting from drive speed.

4 —OVERSPEED GOVERNOR
Senses a predetermined excessive speed to prevent drive overspeeding.

5 —MAIN SYSTEM RELIEF VALVE
Overload protection for hydraulic system.

6 —DIFFERENTIAL GEAR SECTION
Ring, sun and planet gears. Also includes take-off gears for governors, scavenge and make-up pumps.

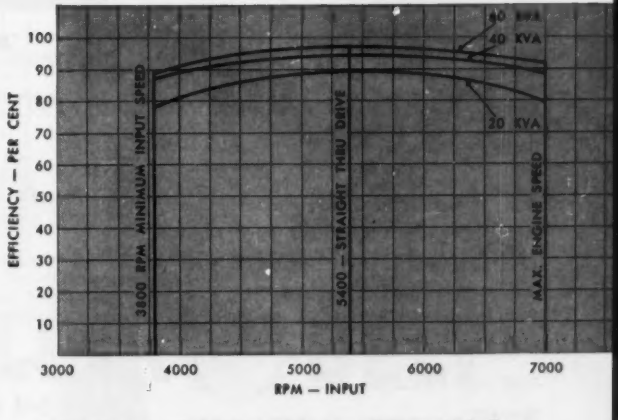
7 —FIXED DISPLACEMENT MOTOR/PUMP
Drives, or is driven by, sun gear to control output speed at 6000 rpm in response to fluid flow exchange with variable delivery unit.

A SIGNIFICANT ADVANCEMENT—

Differential Type Constant Speed Drive For Aircraft Alternators

Tests now in progress on this 60 kva Vickers Differential Type Constant Speed Drive are proving its outstanding performance. (See curves) It combines Vickers dependable hydraulic pumps and motors with planetary gearing to provide a more efficient and lighter "package" than drives now available.

The differential type constant speed drive is a direct engine-driven transmission that can be either engine pad mounted or universal shaft driven. It employs the "differential drive" principle wherein the planetary gear train is the principal power vehicle and the hydraulic components differentially add or subtract speed and power to maintain constant output speed. For further information, write for Bulletin A-5221.



Performance of Vickers 60 kva Differential Type Constant Speed Drive at three different loads. The high efficiency requires minimum support equipment for cooling with minimum penalty for high temperature operation (400°F oil temp.)

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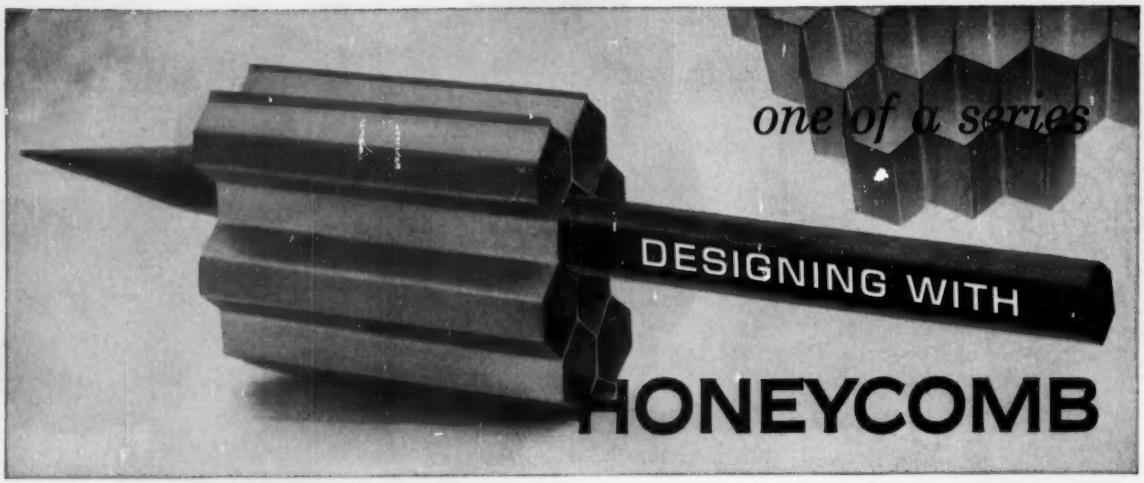
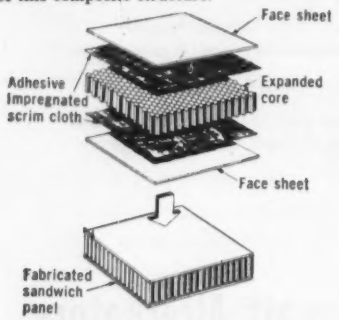
Circle 462 on Page 19



DESIGNERS' CHOICE: Materials for HONEYCOMB SANDWICH STRUCTURES

Honeycomb sandwich structures are composed of thin, high strength facings integrally bonded to light weight core material. The selection of materials to be used in such a structure is of primary importance in arriving at a satisfactory design providing optimum performance.

Figure 1 illustrates the three primary parts of this composite structure.



Facing Selection

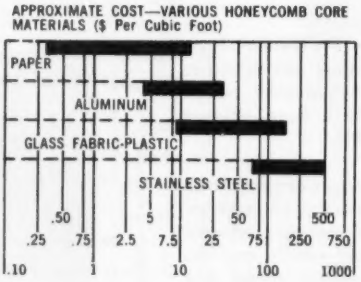
Generally the facings in a sandwich structure are selected in order to provide the highest compressive strength-to-weight ratio economically available in the size range under consideration. Examples of facings on successful sandwich applications are carbon steel in thicknesses of .030 to .050 for heavy duty flooring applications; aluminum alloy 7075 T6 in thicknesses of .010 to .093 for flooring and highly stressed panel applications, and porcelain enamel steel in 14 to 24 gauge for exterior curtain wall applications. Other special applications have dictated the use of high temperature reinforced fiber glass-plastic skins, stainless steel skins, cement asbestos board skins and similar materials. In every case, the facing selection must meet the multiple criteria of economy, structural efficiency, and process compatibility.

Adhesive Selection

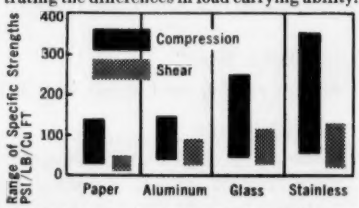
There are now available to designers a number of adhesive systems for attaching honeycomb core materials to high strength facings. Most high strength structural adhesives are based on various combinations of thermosetting resins which provide structural integrity throughout the environmental conditions encountered. For lightly loaded panels subject to less exacting environmental conditions there are a number of adhesives based on thermoplastic or elastomeric resins, some of which permit very economical sandwich fabrication.

Honeycomb Core Selection

Core materials are selected on the basis of structural performance, environmental requirements, and economy.



It can be seen that the cost of honeycomb core materials varies considerably. It should not be inferred, however, that the performance of a particular core is measured by its cost. Figure 3 indicates the specific strength of the same honeycomb core materials illustrating the differences in load carrying ability.



With proper selection of facing, adhesives and honeycomb core, the designer can achieve optimum structural performance with minimum weight. For example, a beam of steel plate weighing 68.6 lbs. can be replaced by a structural honeycomb sandwich beam of 7.8 lbs. with the same deflection and strength.

The design opportunities for honeycomb sandwich structures are apparent.

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

Honeycomb has intrinsic qualities of high strength, light weight, high ratio of surface area to volume and other specific properties which depend upon the type of material used. These combinations of properties, which have given honeycomb wide application in air and space craft, offer to designers in industry generally unique opportunities in product design. In the interest of advancing this knowledge of honeycomb, Hexcel, through its research and development staff (the industry's largest), has prepared this informational series. Should you desire additional technical information or copies of others in this series, please complete the information request form on this page. Your request will receive immediate attention.

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept. "M"
2332 Fourth Street, Berkeley 10, California.

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Executive offices: 2332 Fourth St., Berkeley, California
Plants: Oakland and Berkeley, California; Havre de Grace, Maryland
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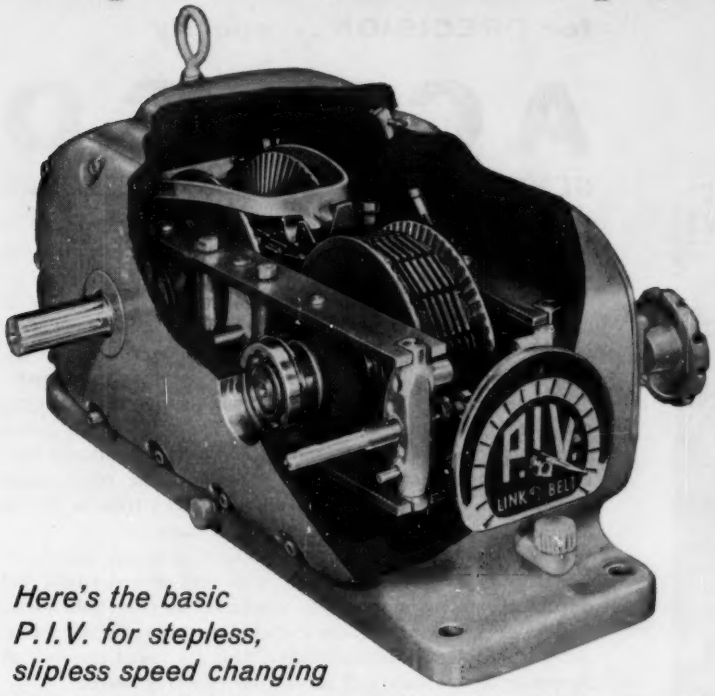
LINK-BELT P.I.V. is available in all these ways for

super-sensitive quality control



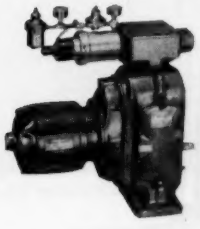
Here's the basic P.I.V. for stepless, slipless speed changing

Today a growing number of production machines and operations demand extremely accurate transmission of power with variable speed control. For these requirements, Link-Belt P.I.V. is available in the many ways shown below—with automatic controls and integral differential to satisfy an infinite number of variable speed applications.

Variable from top speed to minimum speed with no steps, no stops in between, Link-Belt P.I.V. is industry's only chain-driven variable speed drive. Teeth—not tension—permit positive, high-efficiency power transmission.

For information on the full P.I.V. line, call your nearest Link-Belt office. Or write for Book 2274 on basic P.I.V., Book 2349 covering automatic controls and Book 2774 explaining P.I.V. with integral differential.

Link-Belt P.I.V. is available in 8 sizes and 16 standard types, in capacities from ½ to 25 hp—for horizontal or vertical mounting. Compact design simplifies installation as a separate unit or a built-in part of a machine. P.I.V. is totally enclosed, automatically lubricated.



PNEUMATIC (shown) — The P.I.V. pneumatic ratio changer is used as a final control element providing fully automatic control of speed. Operates from standard pneumatic controller in systems regulating pressure, temperature, rate of flow, etc.

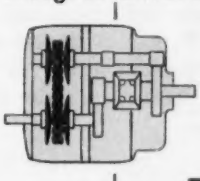
MECHANICAL — Predetermined timing, cyclic, or characterized regulation can be accomplished by P.I.V. with mechanical controls.

HYDRAULIC (shown) — Consists of a low-pressure hydraulic Servo system with a precision valve positioner. Intended to give automatic speed control by direct operation with any form of linkage. A minimum operating force is required.

ELECTRONIC — Flexible form of speed control to provide either "on-off" or modulated speed response of P.I.V. drive. Electric control motors are available to match a wide variety of electrical control systems.

P.I.V. with integral differential gearing

CONDENSED SPEED RANGE TYPE of integral differential results in a ratio range less than a standard P.I.V. with the advantage of increased horsepower capacity, high ratio stability and accuracy. These drives are applicable wherever small ratio range is required but with extreme accuracy of ratio control.



EXTENDED SPEED RANGE TYPE of integral differential results in infinite ratio range and output speeds down to zero with a constant input speed. Clockwise and counterclockwise rotation through zero is also obtainable. These drives may be used whenever a ratio range greater than 6 to 1 is required.

LINK-BELT P.I.V. VARIABLE SPEED DRIVES

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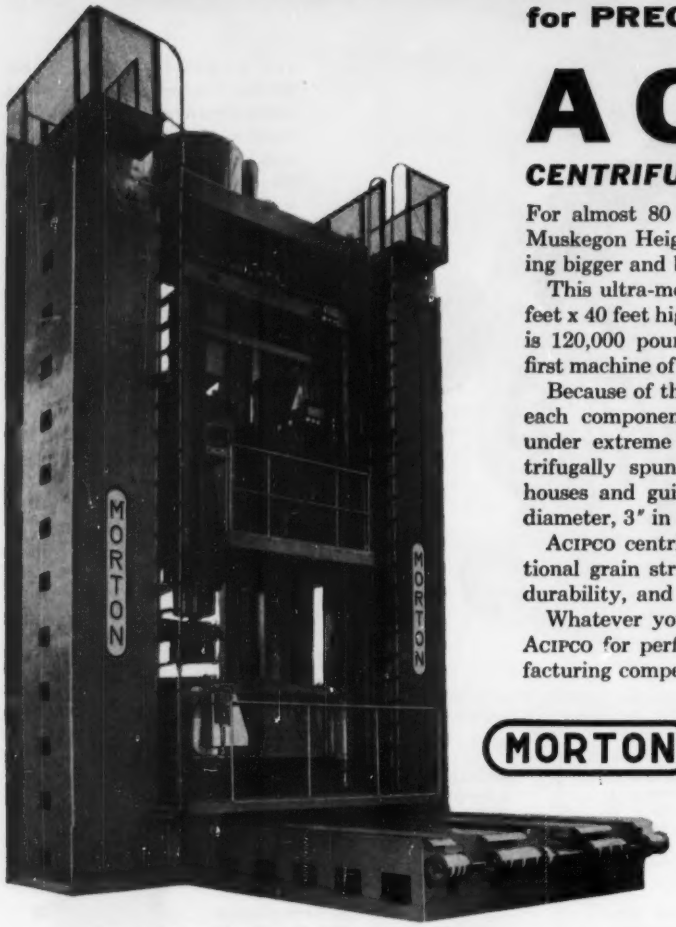
Exacting Requirements?



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For almost 80 years, Morton Manufacturing Company of Muskegon Heights, Michigan, has been progressively building bigger and better machine tools.

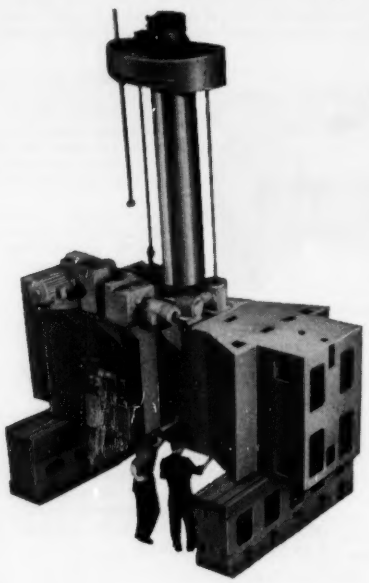
This ultra-modern turning and boring mill is 27 feet x 22 feet x 40 feet high, and weighs 525,000 pounds. Load capacity is 120,000 pounds. Driven with 210 horse-power, it is the first machine of its type wherein the work remains stationary.

Because of the herculean task this machine must perform, each component must be capable of precise performance under extreme loads. Morton wisely selected ACIPCO centrifugally spun steel tubing for the gigantic quill which houses and guides the rotary spindle. This tube is 24″ in diameter, 3″ in wall thickness and 17′6″ long.

ACIPCO centrifugally spun tubes have a dense, non-directional grain structure that has extra-ordinary strength and durability, and is more easily machined to close tolerances.

Whatever you may have in tubular applications, call on ACIPCO for perfect dependability. Our technical and manufacturing competence will serve your exacting needs.

MORTON



Morton Manufacturing Company, of Muskegon Heights, Michigan, is a leading manufacturer of heavy duty machinery for the machine tool industry. Boring mills; drillers, planers, as well as special machine tools for national defense and the development of new processes are among their products.

ACIPCO Centrifugally Spun TUBES

SIZE RANGE: Lengths up to 410″ have been produced to meet modern machinery requirements. OD'S from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION

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ACIPCO

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Circle 466 on Page 19→

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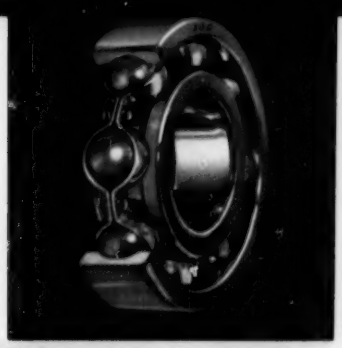

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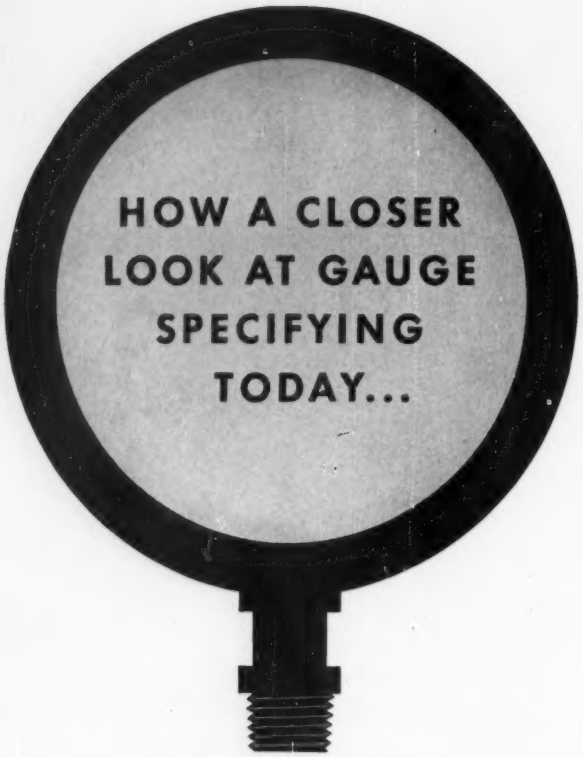

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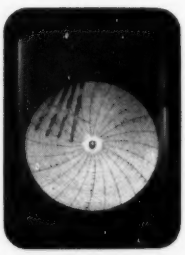
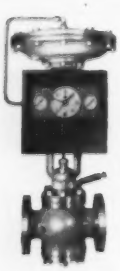
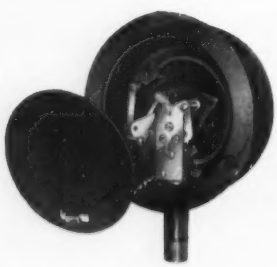


Recorders and Recorder-Controllers

Drawn Case Gauges (Brass or Steel)



Indicating "Pilot" Controllers and Transmitters



Solfrunt® (Supergauge) with blow-out back

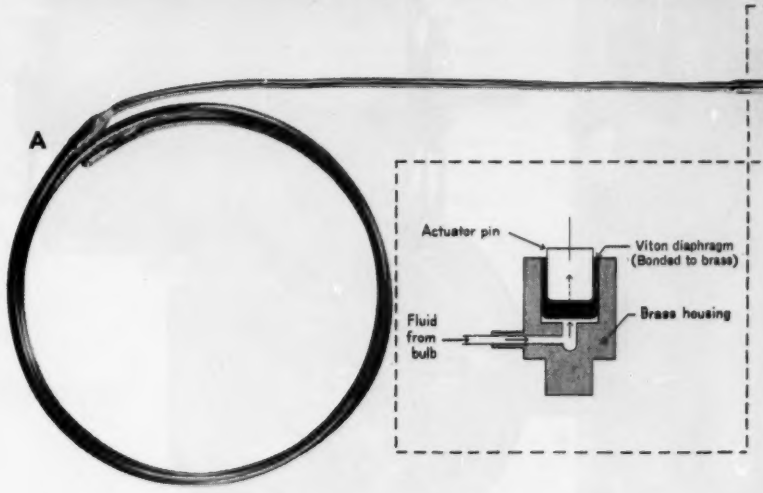
Supergauge® (A.S.A. Grade AA) Line

A-Line (A.S.A. Grade A) Gauges

Drawn Case Thermometers, too

Circle 467 on Page 19

This improved thermostat couldn't work without **VITON**®



Actual size of thermostat

HOW IT WORKS—Heat-expansible fluid inside the bulb (**A**) expands through copper tube to thermostat (**B**). Fluid exerts pressure against VITON diaphragm inside thermostat. Diaphragm pushes against a metal actuator pin which trips electrical contact or control valve. VITON synthetic rubber provided the necessary fluid and heat resistance that made this design practical.

Instrument designers have long recognized the advantages of using a thermostat with an elastomeric diaphragm for electric and gas ranges as well as other appliances. Such a thermostat could be made smaller than bimetallic or metal diaphragm types, would be much more sensitive to temperature changes, operate more quickly—and cost less.

But, until recently, no elastomer was available that would hold up in service. Those tested swelled in contact with the heat-expansible fluid used in the thermostat or they were unable to stand the high operating temperatures. Either the heat or fluid always destroyed the thermostat's accuracy . . . if not the synthetic rubber diaphragm itself.

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As a result, a completely practical elastomeric thermostat is now available. Its bulb volume is roughly ⅛ that of diaphragm-type thermostats previously used. It operates quicker and with greater sensitivity to temperature changes than other types . . . and can be fabricated at much lower total materials cost.

Wherever *you* need an elastic material that can stand high temperatures (450° F. and up), oils, solvents, chemicals . . . and offer outstanding mechanical properties as well . . . consider VITON. For more information about this new synthetic rubber, write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-6, Wilmington 98, Delaware.

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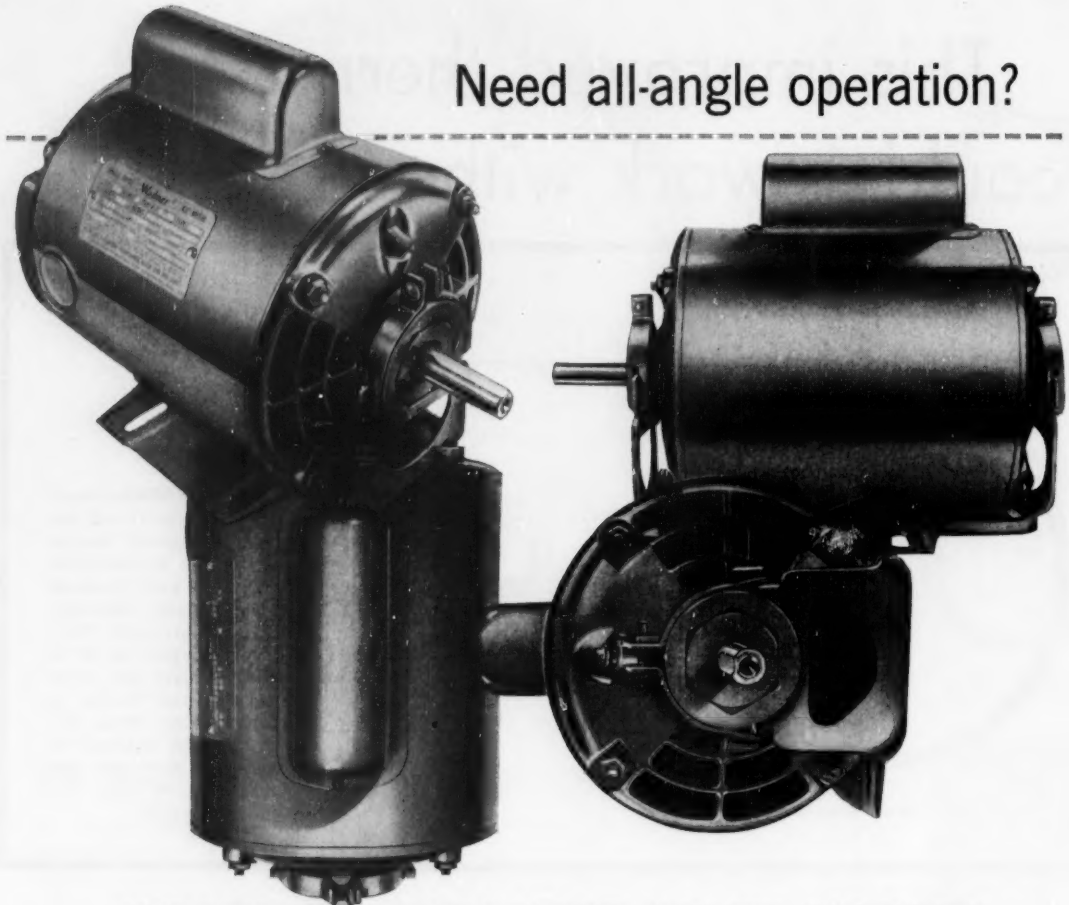

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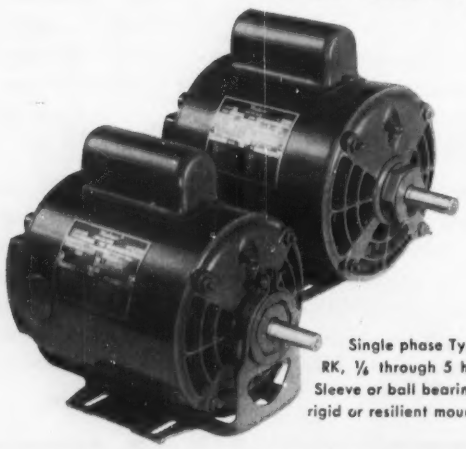
pack more power into less space!



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WM59-6

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—specify the Detroit S-25 solenoid valve. It gives positive opening and closing from ¼ to 6 gpm—2½ to 200 psi—up to 180°F*. The valve has an optional flow control device built into the outlet to insure accurate water delivery. It's available with pipe, tubing or hose connections and with a wide variety of terminals. Many different mounting brackets can be obtained. Listed by Underwriters' Laboratories.

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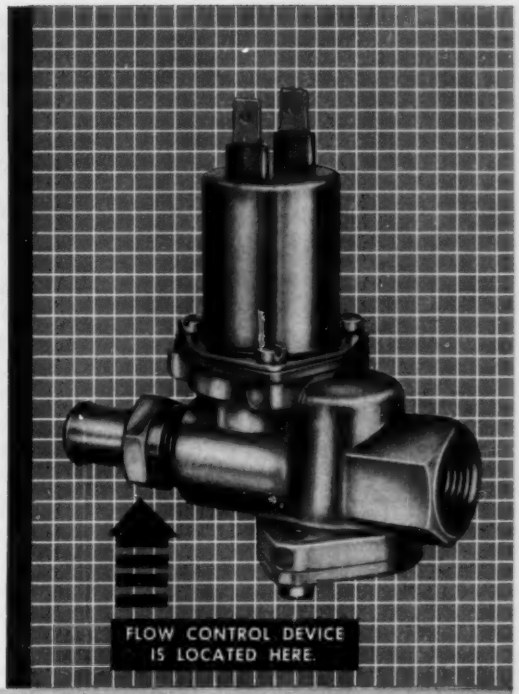

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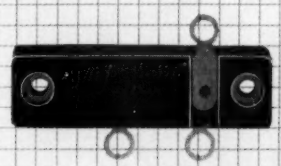
DETROIT CONTROLS DIVISION

CLASS 1



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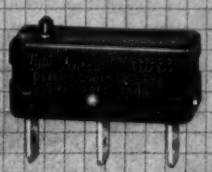
LENGTH 1-5/8"—WIDTH 7/16"—DEPTH 11/32"

CLASS 4



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If you are controlling

Electric Current Flow

—and want positive action in a small space, look to a Detroit TyniSwitch®. These miniature snap switches give you the long life and precision you need, are virtually bounceless and resist shock and vibration. Class 1 TyniSwitches are top mounted and top actuated and Class 4 all side mounted and top actuated. Both have a wide variety of actuators and terminals. Listed by Underwriters' Laboratories.

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Canadian Standards Assoc. approved.
15 Amp. 125/250 V. A.C. Non-Ind. 1/2 H.P. 125/250 V. A.C.
Contractual approvals for U.S. Gov't applications

Circle 470 on Page 19

If you are in the market for rugged, dependable bushings and bearings at an *economical* price—products that provide maximum protection in almost *any* type of equipment—choose from Johnson's . . .

● *Bronze on Steel* ● *Rolled Bronze* ◯ *Babbitt on Steel*

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for maximum protection of your equipment

Bronze on steel thin-wall bushings are economical and practical. Plain or flanged half bearings are available also, precision machined to fit your application. This material also can be furnished stamped for plates, washers and other flat bearing surfaces.

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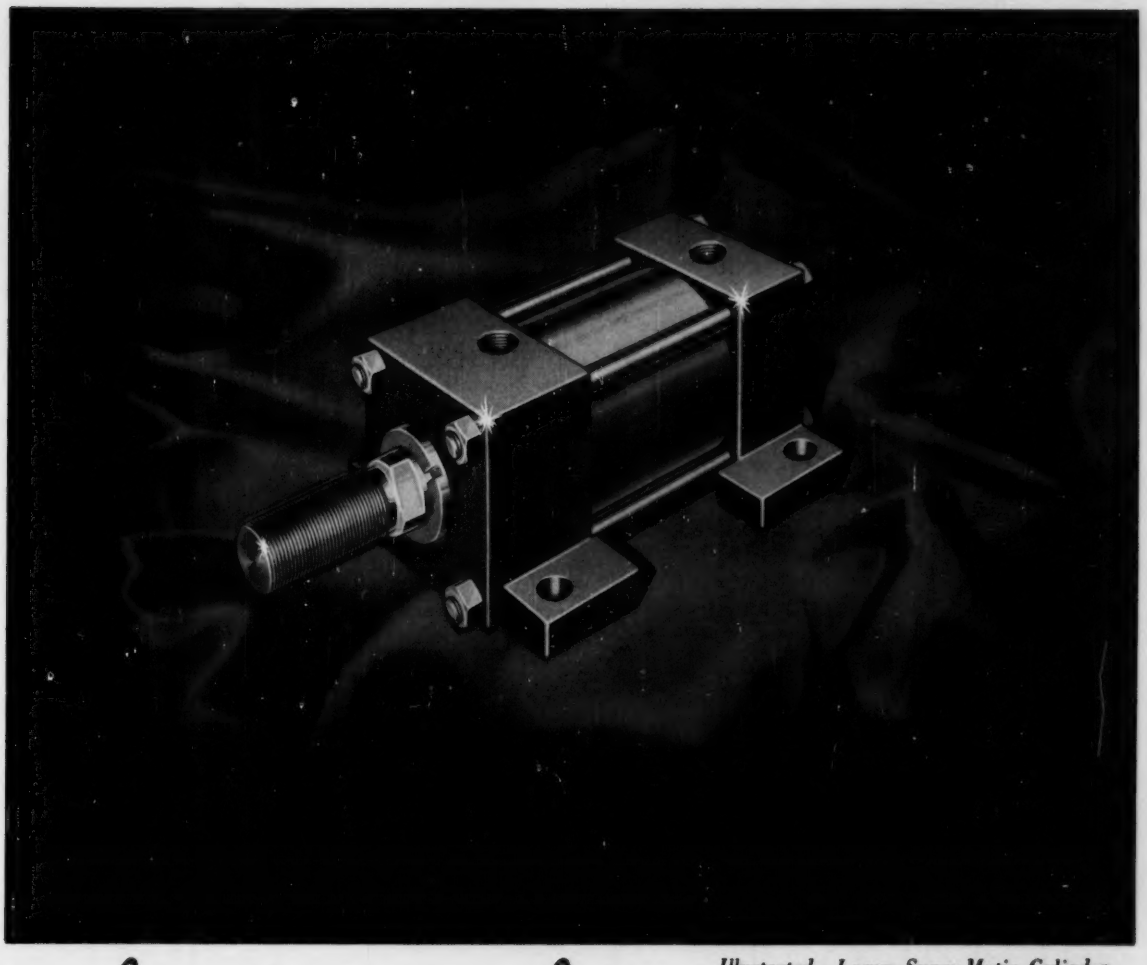

Illustrated—Logan Super-Matic Cylinder Meets J.I.C. Standards

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the ultimate in hydraulic cylinder design

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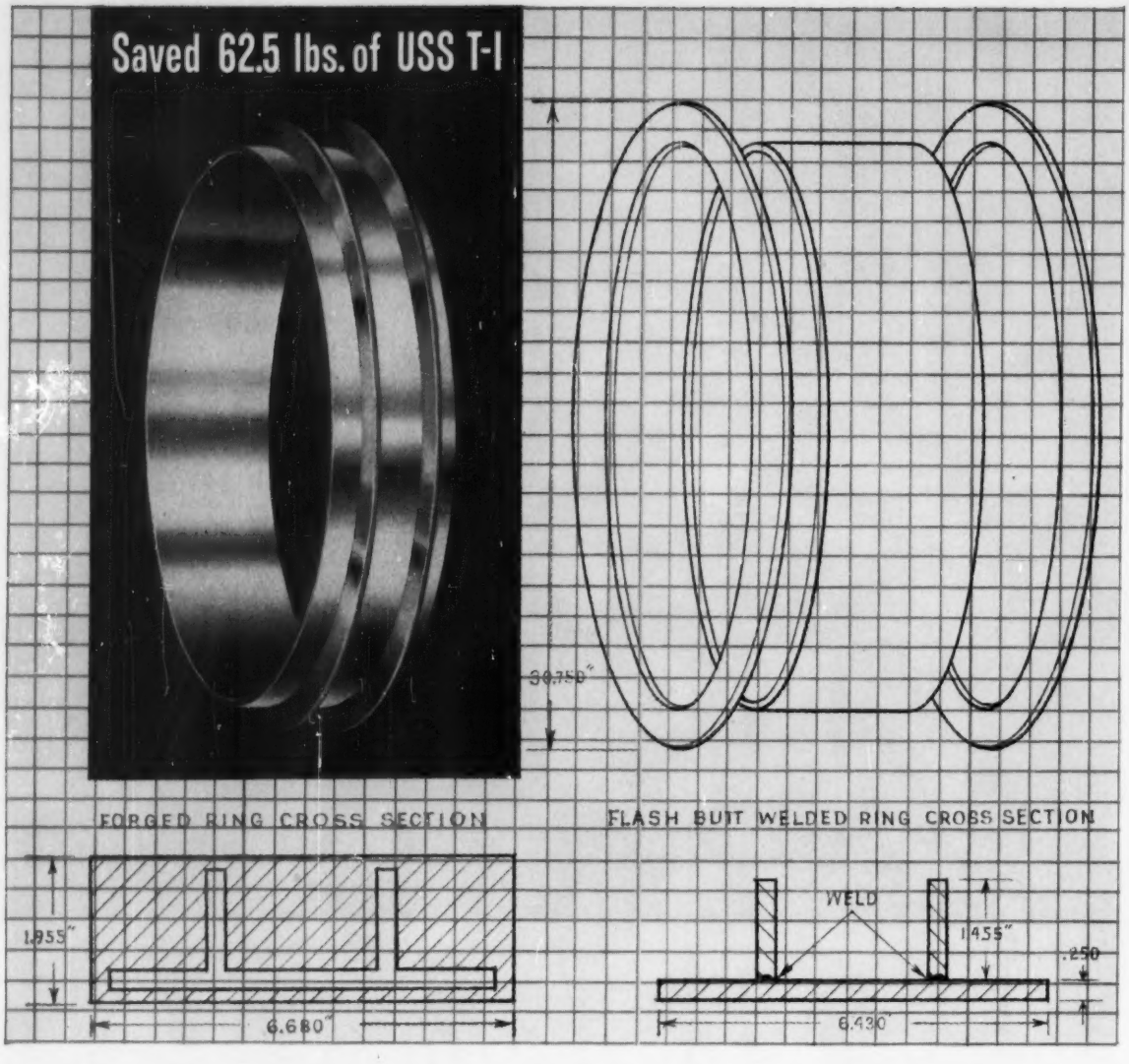

Flash Butt-Welded Rings Instead of a Forged Part SLASHED $50.43 on Sway Brace Ring

By circumferentially welding two flash butt-welded rings around a flash butt-welded band, Amweld engineers eliminated a bulky forged ring and hours of machining. The finished part, a sway brace ring for a jet engine, met manufacturer's critical requirements for aircraft use.

Savings like these have been effected on a wide variety of aircraft and missile parts, particularly where high-strength, high-temperature alloys were involved.

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AMERICAN WELDING

Circle 473 on Page 19

PROGRESS IN PLASTICS

NEW FLAME-RETARDANT EPOXY LAMINATES OFFER HIGH STRENGTH-WEIGHT RATIO, LOW LOSS

Much is being said lately about the fabulous epoxies. No better use, however, has been made of these remarkable resins than the development by CDF of new improved laminates for electrical-insulating purposes.

New CDF epoxy Dilecto laminate exhibits flame-retardancy in simple match test.

CDF epoxy Dilecto® laminates, made with either treated glass-cloth or cellulose-paper base, combine the highest strength-to-weight ratio and the highest impact strength with low water-absorption, low loss properties, and improved machinability. The new epoxy Di-Clad® laminates for printed-circuit use also display exceptional foil-bonding strength, high hot-solder-resistance, and higher maximum operating temperatures than previously obtainable in standard laminates.

And now permanent flame-retardancy and excellent arc-resistance are added to many grades of epoxy laminates from CDF, both GB and XXXP. These laminates, known as the EFR series, meet NEMA G-11 and MIL-P-18177B, Type GEB. This combination of properties should further widen the range of applications for this superior insulating material. CDF Technical Bulletin 11200 describes epoxy Dilecto and Di-Clad laminates in detail.

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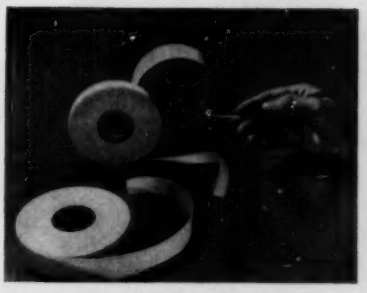
Replacing heavy, costly wooden cases for the transport of delicate aircraft and electronic instruments, CDF now offers fiberglass-reinforced polyester cases containing integral rubber-coated kapok cushioning, built for repeated usage with a wide range of instrument sizes and shapes. The complete line of new CDF instrument-shipping cases ranges in size from 12" x 14" x 7" to 25½" x 11" x 12½".

Measuring instruments packed for shipping in CDF laminated-plastics cases.

Savings through use of these cases are realized in original cost (10% lower than for wooden cases) and in their long useful life without wear or breakage. Request Bulletin MHC-591.

SKIVED TAPES OF UNSUPPORTED TEFLON

Four new grades of tape, made of skived duPont "Teflon" TFE fluorocarbon resin, are now available from



CDF. Excellent electrical properties, resistance of all common chemicals, and a low coefficient of friction characterize these new tapes, designed primarily for high-temperature and high-frequency wire and cable insulation. However, they may be used also as stock from which gaskets, seals, and miscellaneous small parts can be cut.

CDF tapes of Teflon range in width from ¼" to 12" in ⅛" increments, in thickness from .002" to .100". Request Technical Bulletin 97.

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Circle 474 on Page 19

CARL S. HARVEY, *Technical Director, Lamson & Sessions, tells why...*

You overspend when you overspecify... on fasteners

Overspecifying can be costly in ordering fasteners . . . especially in view of the trend toward higher "physicals" and correspondingly higher component costs.

Here's a typical example: A customer specified AISI 1137 steel (a screw machine grade) for a nut. After a look at the "physicals" we recommended a cold forged nut of AISI 1030 steel (a straight carbon steel) and met all requirements at considerably lower cost to the customer.

In many instances we're recommending ordinary grades of carbon steel over the customer's specs of low alloy content material. Our improved heat treatment practices make the savings possible. Elementary cases, perhaps, but they happen every day!

Take Advantage of the specialized experience and facilities available to you through L&S. Leave reference to "chemistry" open. Tell us what you want in end results. Give us the "physicals" and tolerances—then stop! This helps us save *you* money, in both purchasing costs and assembly costs.

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Circle 475 on Page 1

MACHINE DESIGN

June 25, 1959

The Metrological Dilemma

PRESSURES for shifting to the metric system are growing.

Recent agreement by English-system countries on 25.4 mm per inch, instead of 1/0.03937 (25.40005+), is viewed as a clarifying prelude to conversion.

A committee of the American Association for the Advancement of Science is studying the problems involved in shifting to the metric system.

Lewis L. Strauss, Secretary of Commerce, has just directed the Bureau of Standards "to establish an advanced planning group to assemble all available documentation and to identify possible courses of action."

Certain U. S. industries are already on the metric system. Several other industrial nations have converted in recent years.

The pros and cons will tire our ears as they echo up and down the land. Many a debate will end with words to this effect:

"I would agree, if we could make a clean start. But the change is impractical now and, besides, it would cost fortunes."

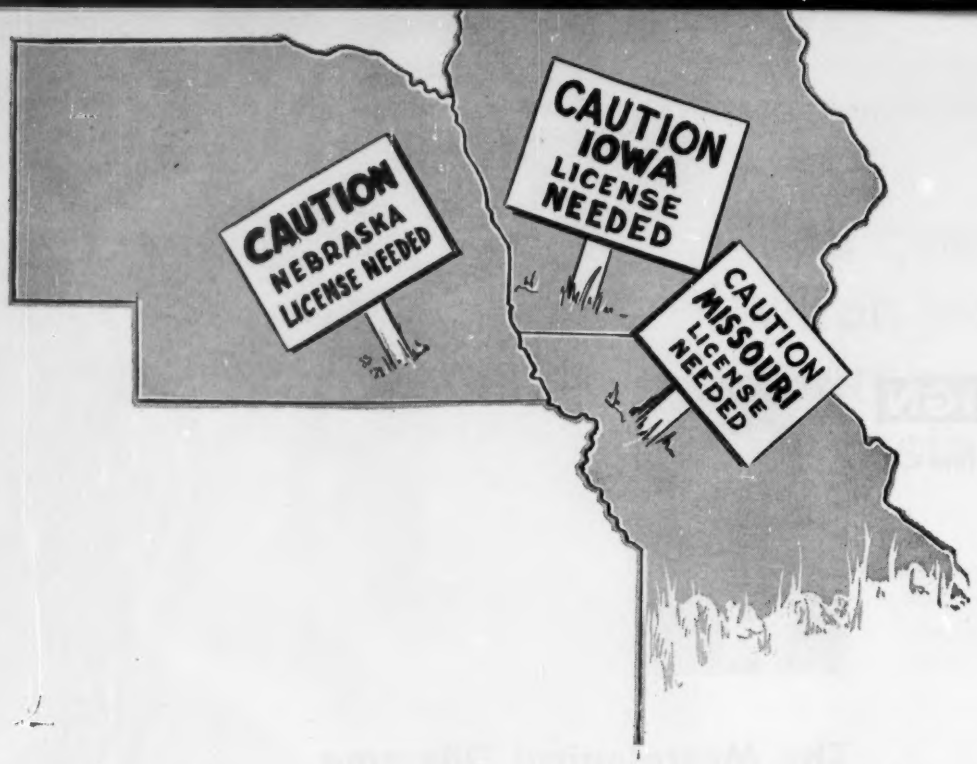
No advocate proposes instant change, nor does he deny the cost. But he promises untold time savings in computations, improved national security, and stronger competitive position in foreign markets.

What would you do if you were asked to study the question for your company or industry? What decision would you recommend? If it favored the change, how would you program the transition? Write and tell us—we'd like to hear about it.

Or, would it be easier to convert the rest of the world to inches?

Ben Hummel

ASSOCIATE MANAGING EDITOR



Problems the Professional Engineer Faces in . . .

REGISTERING IN OTHER

JOHN D. CONSTANCE
Engineering Registration Consultant
Cliffside Park, N. J.

THERE'S NO TELLING where a licensed engineer's job may take him. Throughout his career, chances are he'll move from state to state a number of times. Since that's the nature of his job, he must see that geographic boundaries do not limit his practice. This article tells how states accommodate the nomadic engineer who wants to be licensed, and what he must do on his own.

Licensing of engineers is a function still cherished by individual states. Small wonder that there are differences from state to state! Then, too, state boards have multiple missions. On the one hand, they are charged with promoting and facilitating the flow of engineering talent across state lines. On the other hand, they must prevent the use of interstate registration as a means of getting around tough licensing requirements. A uniform registration law is advocated by the National Council of State Boards of Engineering Examiners (NCSBEE),* but variations of needs from state to state work against it.

Fortunately, engineers licensed in one state may practice for a short time in another without getting a second license. Some states permit this for the duration of one project; others permit practice for definite time periods. In Ohio, the limit is 60 days; in New York, 30 days. A few states permit temporary practice beyond the legal limit if an application is in process. Check with state board secretaries for details.

Licensing by Endorsement: Nearly all state boards of registration grant licenses to applicants registered elsewhere. Requirements differ from state to state, but written and oral examinations are waived if the

*P. O. Drawer 1404, Palmetto Life Building, Columbia, S. C. T. Keith Legare, executive secretary.

Alaska | Canal Zone | D.C. | Hawaii | Puerto Rico

States (shaded) which co-operate by endorsement on the basis of registration examinations taken elsewhere.

STATES

applicant has passed a reasonably equivalent written examination in another state, or if the applicant is a registered professional engineer with an established practice of long standing. Most states require that the applicant be registered in his home state. Of course, the applicant must meet such statutory requirements as age, citizenship, and experience.

Applicants may be considered for a license by endorsement if they hold:

1. License or certificate to practice professional engineering issued after examination by a legally constituted board in any state or political subdivision of the United States.
2. Certificate of qualification issued by NCSBEE.

Provided that:

1. When the license or certificate was issued, the issuing state's examination was the full equivalent of the

Exceptions are:

Arizona
Complete qualification under law.

California
May be given 45 minute to 3-hour individual examination. Applicant must appear before the board.

Colorado
Only on eminence clause.

Delaware
Decided on merits.

Florida
Must take written examination.

Kansas
Minimum requirements under law.

Maryland
Must meet requirements of law.

Mississippi
Minimum requirements under law.

Nevada
All applicants appear at board meeting for oral interview.

North Carolina
Provides for absolute reciprocity on examination basis. Honors all written examinations given by other states.

Oklahoma
Special agreements with other states.

Tennessee
Each case considered on own merits.

Utah
Qualifications under Utah standards.

Virginia
Gives an oral examination if applicant did not obtain registration previously by written examination.

current examination in the state in which the application is being filed.

2. The applicant's record meets all other statutory requirements such as age, citizenship, education, experience, and character.

According to NCSBEE, 46 states give maximum credit to examinations given by other states. California and Nevada require an oral examination regardless of written examinations taken elsewhere. North Carolina recognizes examinations given by only those boards with which it has reciprocal agreements.

Reciprocity: A special case of registration by endorsement, reciprocal registration involves mutual agreement between two or more states to grant registrations, carte blanche. This practice presupposes equality of qualification requirements. Since most states waive examinations for registration by endorsement, reciprocal agreements in addition have been found unsound.

States with high standards balk at lowering them to enter into reciprocal agreements. However, through NCSBEE, state boards are trying to develop a minimum national standard.

Of the 52 boards, 50 honor a request from out-of-state boards for a candidate's grades on his written examination, and 46 honor a request for a copy of his examination.

Certificate of Qualification: A function of NCSBEE is the National Bureau of Engineering Registration (NBER)†. It was established to minimize effort and expense when registered engineers apply for out-of-state licenses. NBER is a fact-finding and certifying agency serving as a clearing house for professional records of engineers.

NBER reviews an engineer's record of experience and investigates his registration with his home-state board. If results of the investigation are satisfactory, NBER issues a Certificate of Qualification.

The certificate is a verified record of an engineer's experience—not a national licence. It helps competent engineers to cross state lines, and it prevents duplication of effort by state boards. Some states accept the certificate as meeting all state requirements for engineering registration. Others accept it in part. An investigation by NBER often takes considerable time, so an engineer should not wait until he actually needs a certificate to apply.

Conditions for Endorsement: Through its Committee on Registration by Endorsement, NCSBEE has devoted many years to the problem of interstate registration. The committee has explored the conditions with state boards and has compiled a list of exceptions, see map table. Requirements change from time to time, so engineers should check with state board secretaries. They have the last word.

†Same address as NCSBEE.

Tips and Techniques

Determining Strains Graphically

To simplify strain calculations by constructing a Mohr's circle, a simple template, which reduces the complexity of the construction, can be used. In addition, the method is self-checking.

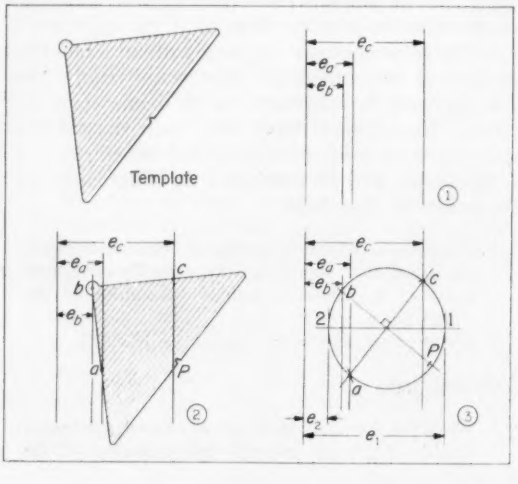
The template is essentially a 45-deg triangle with equally spaced lines drawn parallel to the hypotenuse. A pivot point is located at the apex of the triangle and the center point of the hypotenuse is marked.

The simplified method for constructing the Mohr's circle is as follows:

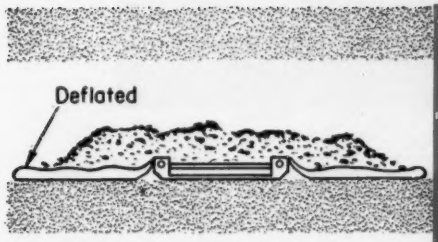
1. Choose a convenient scale along the horizontal axis and lay off vertical lines to represent strains e_a, e_b, and e_c, Fig. 1.
2. Place the pivot point of the template on line e_b, at a point b, and rotate the template, using a pencil as the pivot, until one of the cross lines intersects the e_a line at one edge of the template, a, and the e_c line at the other edge, c. Mark the intersection points and the center-line extremity, P, on the graph paper, Fig. 2.
3. The Mohr's circle is constructed using the intersection of the two perpendicular lines, ac and bP, for the center. Principal strains e_1 and e_2 are determined from circle, Fig. 3.

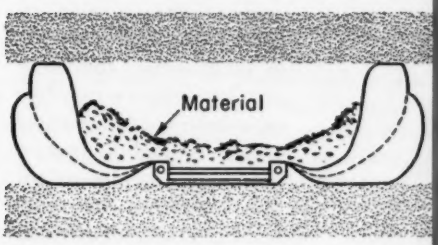
The method is self-checking since the circle must pass through e_a, e_b, and e_c, and these points are respectively 90 deg apart for a 45-deg rosette.

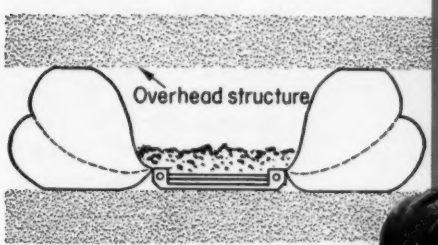
Templates can also be constructed for 60-deg strain rosettes.—H. A. Robinson, *United Shoe Machinery Corp., Atomic Power Dept., Beverly, Mass.*



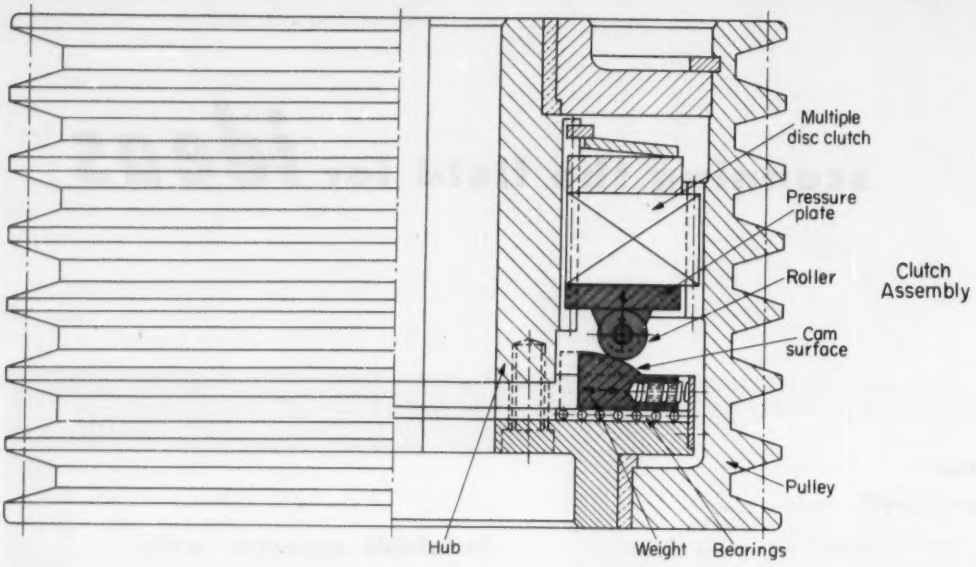
scanning the field for *ideas*

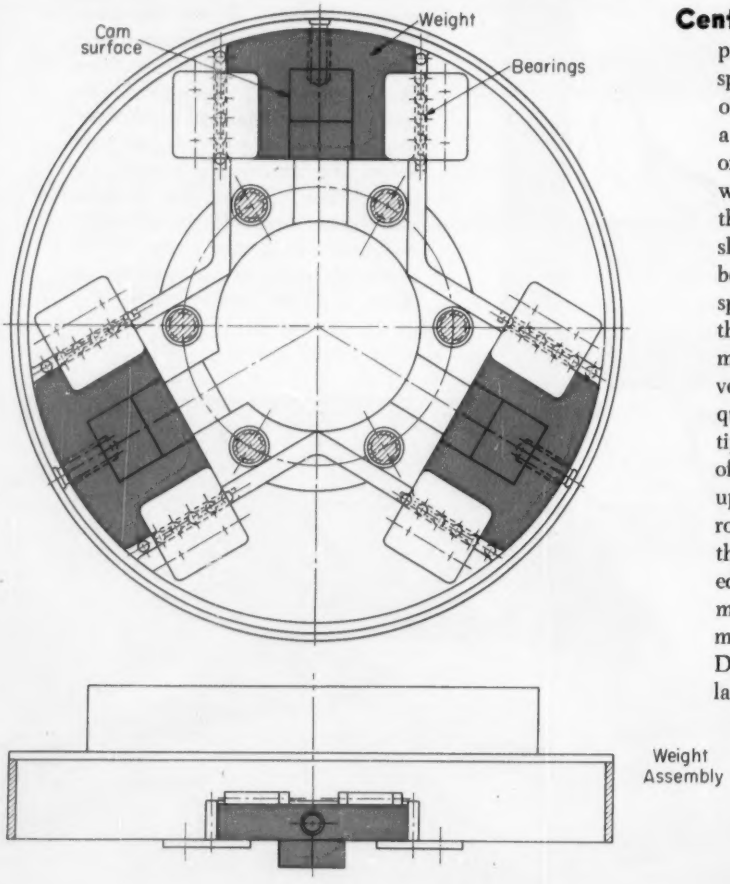






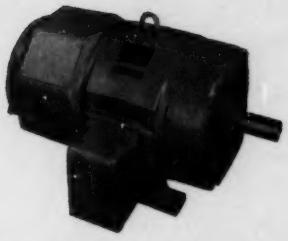
Inflatable conveyor walls facilitate loading and handling of bulk materials when operating space is limited. In the Joy pneumatic feeder, two inflatable neoprene bags flank a conventional chain conveyor. Uninflated, the bags lie flat. Material is dumped or piled over the conveyor and bags. When the conveyor is started, the bags inflate, tipping the material into the conveyor. If over-all height is limited, bags take shape of the overhead structure, producing, in effect, a closed channel unit.





Centrifugal cam action produces linear motion for speed-responsive actuation of multiple-disc clutch. In a pulley design, a cam face on a centrifugally actuated weight is used to operate the clutch. As the weight slides outward on roller bearings at a predetermined speed, a roller attached to the clutch pressure plate moves up the cam face, developing the linear force required to engage the multiple-disc clutch. Force of engagement depends upon cam design, speed of rotation and magnitude of the weights. Clutch patented by Karl Stubner, Germany; available for U. S. manufacture through Rand Development Corp., Cleveland, Ohio.

Where drive speed need not be adjusted, an induction motor is the natural choice. For a nearly constant-speed drive, torque is the chief selection criterion. But character of the drive torque is affected by electrical design of the motor, starting method, and the load itself. Here's how these factors influence selection of . . .



three-phase induction motors

C. H. BUCHANAN
Application Engineer
Small AC Motor Dept.
General Electric Co.
Schenectady, N. Y.

SIMPLE facts of life for a motor are—it must start, accelerate, and drive its load, within certain limitations. More to the point, starting, acceleration, and deceleration must not damage the motor or transfer excessive shock and vibration to the load. At the same time, the motor should not blow line fuses or throw circuit breakers under ordinary starting and load conditions. And under continuous or intermittent operation, the motor must not overheat.

Several "standard" induction motor designs are available to match likely duty cycles and load-torque requirements. They are squirrel-cage motors, designated NEMA Designs B, C, and D motors, and wound-rotor motors. Each of these motor types is best suited for one particular range of application conditions.

After a motor with the right characteristics is selected, a starting method must be chosen. This choice is influenced by allowable acceleration time, motor size, and limitations on current demand.

As a guide to selection, standard induction motors and starting methods are analyzed and compared in this article.

NEMA Design B Motors

In Fig. 1 are typical speed-torque curves of NEMA Designs B and C squirrel-cage induction motors. Throughout the accelerating period until operating speed is reached, torque developed by a squirrel-cage induction motor depends solely on the motor design constants and the voltage applied to the motor.

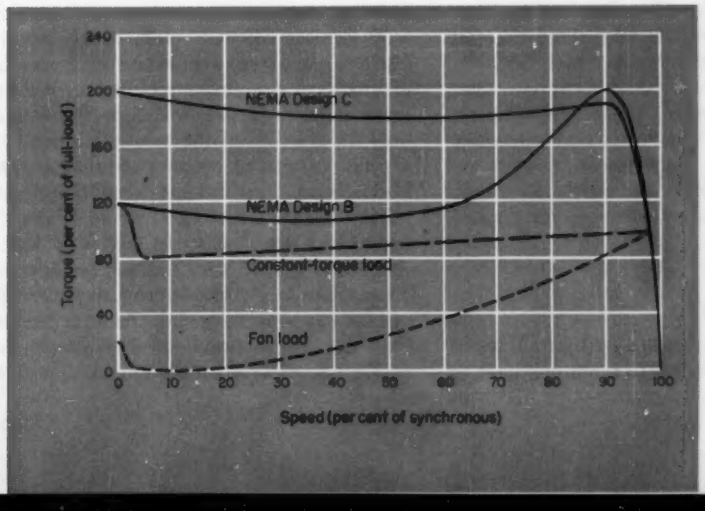


Fig. 1—Typical speed-torque curves for NEMA Designs B and C three-phase induction motors along with curves of a constant-torque load and "fan" load.

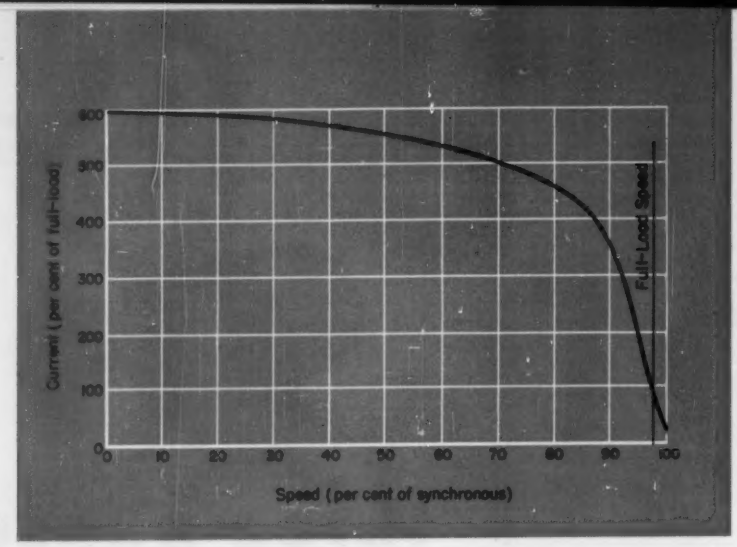


Fig. 2—Speed-current curve of typical NEMA Designs B and C induction motors.

When rated voltage is applied to the terminals of a NEMA Design B motor, it develops 120 per cent of full-load torque at standstill (starting torque), 108 per cent torque at 25 per cent of its synchronous speed, 110 per cent torque at 50 per cent speed, 148 per cent torque at 75 per cent speed, and 200 per cent torque at 90 per cent speed.

The load to which the motor is connected has nothing to do with the torque the motor develops during its accelerating period. The load may affect the duration of the acceleration period but not the torque the motor develops.

Fig. 1 also shows a curve typifying such loads as fans, blowers, centrifugal compressors and, to a lesser degree, machines like drill presses and generators which start unloaded and are loaded only after they come up to speed. This fan-type load curve defines the torque required at any speed to maintain the load at that speed. Any torque the motor develops in excess of that required to maintain the load at a particular speed serves to accelerate the drive.

It takes more torque to break the load away from standstill than it takes to maintain it at 15 per cent of synchronous speed, for instance. This is characteristic, to a degree, of virtually all loads. The reason, of course, is that static friction is greater than sliding or rolling friction. Also, lubrication films may be partially eliminated during standstill and become re-established with motion.

At starting, the motor develops more torque than required to break the load away, Fig. 1. Furthermore, at every point between zero speed and operating speed the motor develops more torque than is required to maintain the load at any particular speed. As a result, the drive accelerates to operating speed and runs there.

NEMA Design C Motors

Shown also in Fig. 1 is a load speed-torque curve usually referred to as a constant-torque curve. It is typical of "friction-type" loads, such as conveyors, mixers, and to a lesser degree, shakers, pulverizing mills, and reciprocating compressors.

If a NEMA Design B is used to drive the constant-torque load in Fig. 1, it appears that the motor develops a starting torque exactly equal to that required to break the load away. Will the motor always move the load from standstill? The answer is that the NEMA Design C motor was developed for just this type of load. The motor and load curves show that this motor develops a comfortable margin of torque above that required by the load at every speed point from zero speed to operating speed.

Torque vs. Voltage: Induction motors are sensitive to applied voltage. Their torque curves are raised or lowered in proportion to the square of the applied voltage. NEMA standards require motors to operate satisfactorily at ± 10 per cent of their rated voltage. Hence, good application practice dictates that a sufficient margin of motor torque above load torque must be maintained even when the voltage is 10 per cent below rated value. Voltage would be 90 per cent of rated in this case, and motor torque would be 81 per cent of its rated-voltage value.

A common rule is that the motor torque curve, at the point where it most closely approaches the load-torque curve, should be at least 30 per cent greater than the torque required by the load at that speed. This rule allows the motor, even developing only 81 per cent of the torque it should, to develop a small margin of torque over that required by the load. Thus, starting and acceleration are assured.

Acceleration Effects: In Fig. 2 is the speed-current curve for NEMA Design B or Design C motors. This curve defines the current the motor draws during its accelerating period. As with torque, the current the motor draws at any particular speed is dependent solely on the motor design constants and

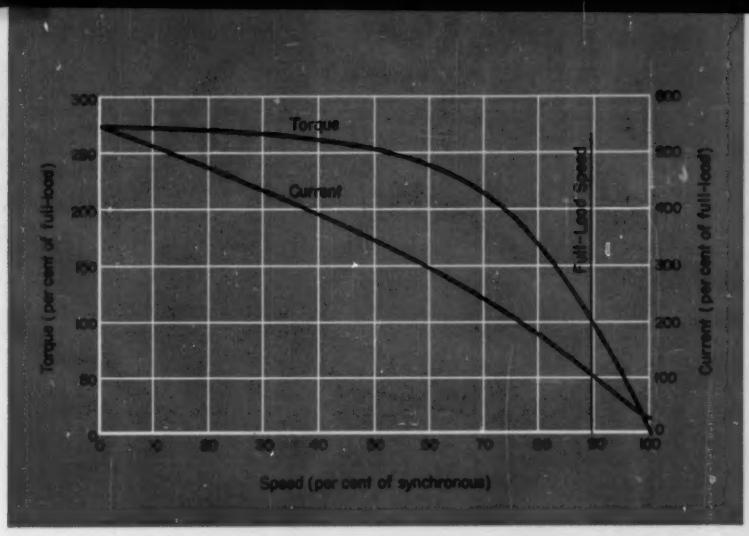


Fig. 3 — Speed-torque and speed-current curves of a typical NEMA Design D induction motor.

not on connected load. Here again the load to which the motor is connected has nothing to do with the magnitude of the current drawn at any particular speed. It may affect the duration of the acceleration period but not the current magnitude.

Once a motor reaches a stable operating speed, however, it is a complete slave to its load. If the load-torque requirement changes, the motor readjusts its own speed slightly to develop torque exactly matching the new load-torque requirement. The starting current is between 500 and 600 per cent of the induction-motor full-load current. It does not drop appreciably below this initial value until the motor has reached approximately 80 per cent of speed, Fig. 2.

NEMA Design D Motors

Motor heating results from motor losses. Nearly all of the motor losses during acceleration are proportional to the square of the current drawn. Motor heating during most of the acceleration period is about 25 times the full-load heating. Obviously, for motor applications involving frequent starts and stops, the motor will heat more than for continuous operation.

In Fig. 3 are speed-torque and speed-current curves of a typical NEMA Design D motor. This type of motor has characteristics which make it ideal for frequent starting and stopping as well as for continuous operation with a fluctuating load, both with and without significant flywheel effect.

Duty Cycles: The speed-current curve of the NEMA Design D motor, Fig. 3, shows that current drops off rapidly as the motor accelerates. For this reason, acceleration heating of a NEMA Design D motor is less than that of NEMA Designs B and C motors. Heatwise, then, a NEMA Design D motor supplies more acceleration per minute than NEMA Designs B and C motors with the same heating.

For fast accelerations and plugging, the NEMA Design D speed-torque curve is preferable to the others discussed because it exhibits the most accelerating torque for a given load and brings the drive up to speed in the shortest possible time. In many duty-cycle applications requiring short accelerating and plugging periods, a NEMA Design D motor is often the only one which can meet the short time requirements.

Fluctuating Loads: If the speed-torque curves in Fig. 1 are compared to the speed-torque curve in Fig. 3, it is apparent that the full-load speed of the NEMA Design D motor is appreciably less than NEMA Designs B and C motors. Also, a given change in the torque required by the load will produce a larger speed change in the NEMA Design D motor than in the other two. Because of these speed-torque characteristics, NEMA Design D motors are often applied on drives where the load torque fluctuates periodically, or where it is desirable to allow whatever flywheel effect or WK^2 there is in the drive to supply part of the energy required to carry the peak load.

Example 1: Assume that a certain application exhibits a fluctuating load torque depicted at the top of Fig. 4. Also, assume that the time interval of the load fluctuations and the flywheel effect are such that a NEMA Design D motor has exactly the correct amount of time to adjust its speed to the low-torque requirement when the high torque is reimposed and vice versa. The NEMA Design D motor speed fluctuations obtained from the speed-torque curve would be as shown in curve *a* of Fig. 4, and the current fluctuations, obtained from the speed-current curve at the speeds corresponding to the load torques, would be essentially as shown in curve *b*.

Similar analysis of the NEMA Designs B and C curves results in speed and current fluctuations in

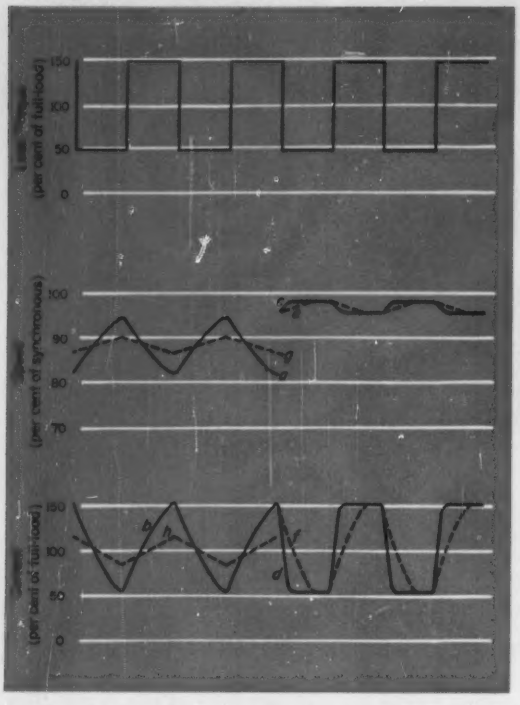


Fig. 4—Effects of a fluctuating load on NEMA Designs B, C, and D three-phase induction motors. The solid curves for speed and torque assume that the time interval of the load fluctuations and the flywheel effect are such that a NEMA Design D motor has the correct amount of time to adjust its speed to the low torque requirement when the high torque is reimposed and vice versa. The dashed lines show what would happen if the flywheel effect were tripled.

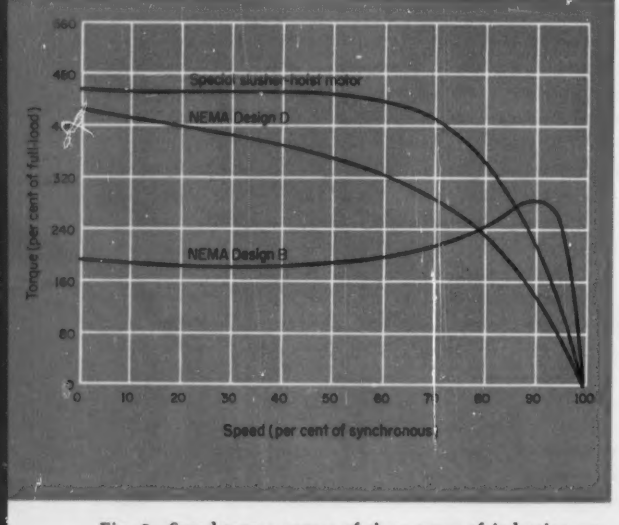


Fig. 5—Speed-torque curves of three types of induction motors applied on slusher hoists.

curves c and *d*, respectively, of Fig. 4. The speed excursion in curve *c* is only about one-fourth that for the NEMA Design D motor shown in curve *a*, and it takes place in one-fourth the time. The reason is simple: The NEMA Design D motor develops much more accelerating and decelerating torque.

Example 2: If the flywheel effect is tripled, the NEMA Designs B and C motors take three times as long as in Example 1 to accomplish their speed excursion. But they still make the complete excursion with attendant current fluctuations as shown in curves *e* and *f* of Fig. 4. The NEMA Design D motor, on the other hand, would make approximately one-third the speed excursion it did previously with corresponding reduction in current fluctuations and line disturbance as depicted in curves *g* and *h* in Fig. 4.

Average currents in both examples of Fig. 4 are the same. But, 50 to 70 per cent of the motor losses and subsequent heating are proportional to the square of the current, and losses produced by currents fluctuating about an average value are greater than those produced by a steady current of the same average value. Reducing current fluctuations cuts motor heating, possibly permitting use of a smaller and less-expensive NEMA Design D motor on a given drive.

Applications: A NEMA Design D motor is a "lazy" motor: It slows down when suddenly loaded and lets the flywheel effect do part of the hard work. NEMA Design D motors are suitable for punch-press drives. The large flywheel effect helps to carry the peak punching load. Motor heating and line-current fluctuations are reduced.

Oil-well pumping, where the motor drives a counterweighted crankshaft, is another example of a fluctuating load which varies almost sinusoidally from no load on the motor to approximately 150 per cent of rated load. Load-torque fluctuations during oil-well pumping are likely to be relatively slow. Hence, either a NEMA Designs C or D motor will have sufficient time to experience a full speed excursion.

From the motor standpoint, slusher hoists present a problem of fluctuating heavy loads. Two or three cable drums are clutched separately or in combination to a continuously rotating motor shaft. Slusher-hoist operation frequently imposes severe overloads on the motor with possible overheating.

Fig. 5 shows the NEMA Design B and NEMA Design D speed-torque characteristics that have in the past been used on slusher hoists compared with the characteristics of a motor recently developed especially for slusher-hoist duty. The curves in Fig. 5 show that the developed torque of the slusher-hoist motor builds up gradually as the motor is decelerated to 50 per cent speed, whereas, the NEMA B curve subjects the equipment to a torque build-up almost equivalent to an impact. The build-up of torque of the NEMA Design D characteristic is not much slower from the impact standpoint than the slusher-hoist motor characteristic.

Wound-Rotor Motors

Depending on the value of the secondary resistances connected across the motor slip-rings, wound-rotor motors can be made to exhibit a wide variety of speed-torque curves, Fig. 6. With the rings short-circuited (1 2/3 per cent resistance), the torque curve is similar to that of a NEMA Design B motor. However, the 20 per cent resistance curve is similar to a NEMA Design D characteristic. Consequently, adjustment of secondary resistance can determine whether the wound-rotor motor acts like a NEMA Design B or NEMA Design D motor or a compromise between them.

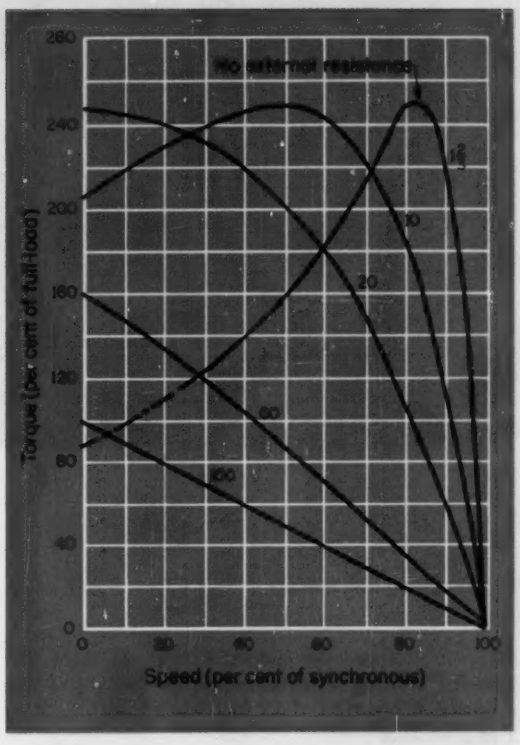
The wound-rotor motor can also be an adjustable-speed motor. For instance, assume that the wound-rotor motor is fully loaded by a constant-torque load. Speed with the rings short-circuited is approximately 97 per cent. A secondary resistance of 10 per cent reduces the speed to 92 per cent; 20 per cent secondary resistance reduces it to 82 per cent; 60 per cent secondary resistance reduces it to 43 per cent.

Ordinarily, a conventional wound-rotor motor should not be operated continuously below 75 per cent speed. Since ventilation is reduced at lower speeds, torque should be reduced to prevent overheating. Also, with slip-ring resistance speed control, efficiency drops off approximately in proportion to the reduction in speed.

Applications: Wound-rotor motors are used on cranes and hoists where not only reduced speeds but also graduated torque steps are desired to handle hook loads gently.

Acceleration losses and heating caused in squirrel-cage motors by the high currents shown in Fig. 2 are drastically reduced during wound-rotor motor accelerations for two reasons. First, as shown by the current curves of Fig. 6, successive cutting out of resistance steps keeps the current low during the accelerating period. Wound-rotor motors are usually started with 100 per cent secondary resistance which is cut out in several graduated steps. Second, most of the accelerating losses which are normally generated in the rotor of a squirrel-cage motor are generated in the air-cooled secondary resistors of a wound-rotor motor.

Since a wound-rotor motor runs cooler than a squirrel-cage motor on a given duty cycle, a wound-rotor motor can be applied sometimes where a squirrel-cage motor cannot.



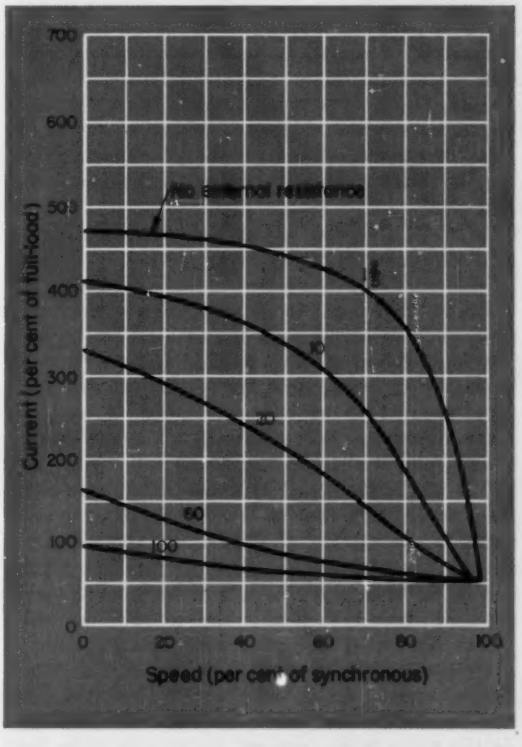


Fig. 6—Speed-torque and speed-current characteristics of a wound-rotor motor with various values of secondary resistance. A secondary resistance of 100 per cent produces 100 per cent torque at standstill on the negative side of the speed-torque curve.

Starting Methods

In general, the chief reason for use of the various starting methods is to reduce the starting-current inrush demand to conform to current limitations set by electric-power companies. Some starting methods are used to reduce accelerating torque for a softer start.

Power companies have two kinds of current limitations. They may limit the total current which can be drawn at any time. Or they may place a limitation on the amount of additional current de-

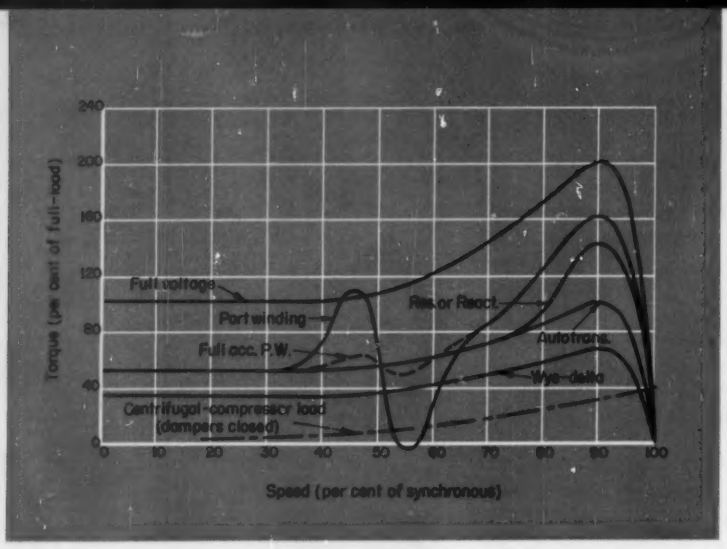


Fig. 7 — Comparison of speed-torque curves of squirrel-cage induction motors for various starting methods.

mand which can be suddenly imposed upon the system, allowing this increment of current to be repeated at specified short intervals of time, such as 1 or 2 seconds.

Across-the-Line Starting: The simplest starting method is, of course, across-the-line starting which uses a standard motor and a standard, full-voltage control, Fig. 7. The speed-torque curve for full-voltage across-the-line starting is shown in Fig. 7. In Fig. 8 is a current-time curve for full-voltage, across-the-line starting as a basis for comparison. The times are typical for the flywheel effect WK^2 as seen by an 1800-rpm motor shaft driving a centrifugal compressor through step-up gearing.

Resistor Starting: In general, resistor starting is used only on low-voltage systems. In this type of starting, resistors are connected in series with motor leads during the acceleration period. As the motor is accelerated to its operating speed, a contactor short-circuits the resistors. With all of the resistors shorted out, the motor operates at full voltage.

The torque developed by a motor during acceleration period with resistor starting is about proportional to the square of the voltage applied to the motor. Consequently, using a 70 per cent voltage tap on the resistor results in a motor starting torque of approximately one-half the torque the motor would develop if it were started across-the-line.

In the region of maximum torque, the speed-torque curve for resistor starting is higher than about the first half of the across-the-line curve in Fig. 7. As the motor picks up speed, the current drops from its standstill value to its full-load value, thereby raising the voltage from 70 per cent of normal at standstill to something greater than 70 per cent of normal when the motor reaches the region of maximum torque.

A squirrel-cage induction motor requires, in general, a starting current of 650 per cent of full-load current. A motor with its terminal voltage reduced to 70 per cent of normal voltage draws 70 per cent of normal starting current or approximately 450 per cent of full-load current.

The variation of current versus time during motor acceleration is shown in Fig. 8 for a typical centrifugal-compressor application. Comparison of the across-the-line and resistor starting curves shows that the current inrush drawn by the resistor-started motor is less than that drawn during across-the-line starting. However, as the speed-torque curve is lowered, starting time is prolonged.

It is sometimes necessary to cut down the inrush current increment to a value even smaller than that exhibited by resistor starting. A logical extension of resistor starting is to provide a resistor with a number of taps, and to cut out successive sections of resistance at short intervals—about 1 or 2 seconds. The increment starter breaks the motor starting current into smaller increments imposed successively.

The high resistance required in increment starting may drop the speed-torque curve of the motor to such a low value that the motor will not start to rotate until some of the resistor steps have been cut out. This is all right since the increment starter is applied where the current increments must be small, but can be added successively.

The resistor steps may possibly be cut out before the motor reaches more than 50 to 75 per cent speed. In this case, the total current drawn by the motor can be as great as that drawn during resistor starting. But the current has been broken into successive small increments which are satisfactory to the power company.

Reactor Starting: A starting method similar to resistor starting is reactor starting. The reactor also reduces the voltage supplied to the motor terminals, and it is designed with taps so that field choice of

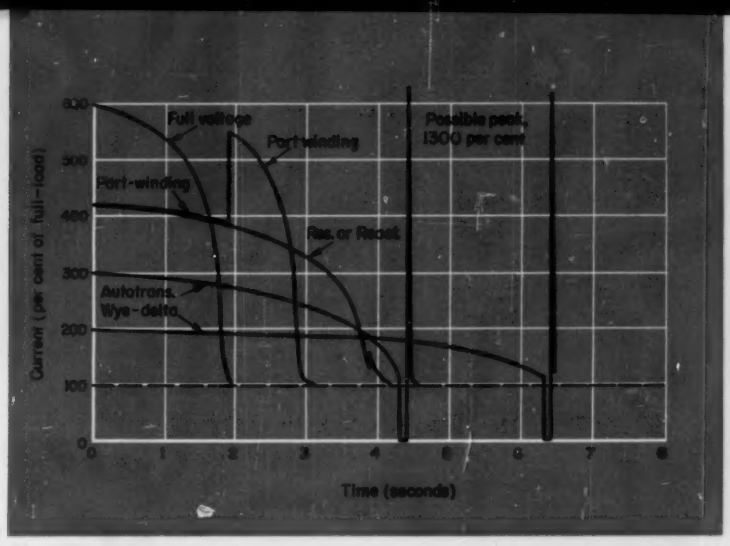


Fig. 8—Comparison of starting currents versus unit time of squirrel-cage induction motors for different starting methods.

the reduced voltage applied to the motor is possible. The speed-torque and current-time curves for reactor starting are so similar to the same curves for resistor starting that identical curves are marked in Fig. 7 and 8. Reactor starting is most suitable for high-voltage applications.

Autotransformer Starting: In autotransformer starting, reduced current inrush to the motor looks like a much smaller inrush as viewed from the power system looking at the autotransformer. Again, for comparison purposes, the autotransformer tap is chosen such that 70 per cent of the line voltage is applied to the motor.

The progressive reduction of current drawn by the motor accelerating from standstill to full speed has no appreciable effect upon the voltage supplied to the motor by the autotransformer. Hence, the speed-torque curve for autotransformer starting is at all points approximately 50 per cent of the across-the-line starting curve.

Again, 70 per cent voltage applied to the motor results in 70 per cent current flowing in the motor but this 70 per cent current as viewed from the line looking at the input of the autotransformer appears as the square of the motor current or 49 per cent of normal full-voltage current.

Comparison of these foregoing three starting methods shows that autotransformer starting produces practically the same speed-torque curve as resistor and reactor starting, but that the current inrush, as seen by the line, is proportional to the square of the voltage applied to the motor terminals. For resistor and reactor starting, it is proportional only to the first power of the voltage applied to the motor terminals.

The chief objection to autotransformer starting is that, unless special equipment is supplied, the motor will be momentarily disconnected from the line before reconnection is made to the full-voltage tap. When reconnection is made on the full-voltage tap, it is entirely possible that a momentary current of high magnitude will be drawn. Special equipment can be supplied to eliminate this disconnection and reconnection. Application of this equipment is known as the Korndorffer method.

Wye-Delta Starting: In this method of starting, the motor is connected to full line voltage during the acceleration period, but the motor connections are made so that the effect is the same as for reduced voltage. The motor must have delta-connected windings for normal operation. By using appropriate control, these windings can be connected in wye during the acceleration period, which has the same effect torquewise as reducing the motor voltage to 57 per cent of normal value.

The speed-torque curve for wye-delta is proportional to the square of effective motor voltage which is 33 per cent of the across-the-line speed-torque curve.

The time-current curve in Fig. 8 exhibits an inrush current value of 33 per cent of normal current, and the extended acceleration time results from the much reduced speed-torque curve.

Wye-delta starting requires momentary disconnection and reconnection of the motor across the line. High magnitude current of 1 to 2-cycle duration may result.

Part-Winding Starting: So-called part-winding starting was developed for motors with standard characteristics to meet power-company inrush limitation requirements where successive current increments of limited magnitude can be imposed. In part-winding starting, a portion of the motor windings is connected across the line to draw a reduced current inrush and, at a specified later time (approximately 1 to 2 seconds), the remainder of the motor windings is connected across the line.

What happens to screw fasteners when loads are rapidly applied? Here are recent findings on

Strength of Machine Screws

at high loading rates

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Research Laboratory
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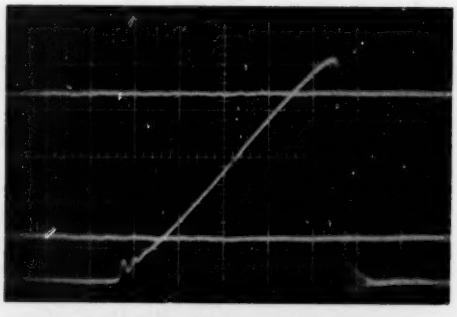
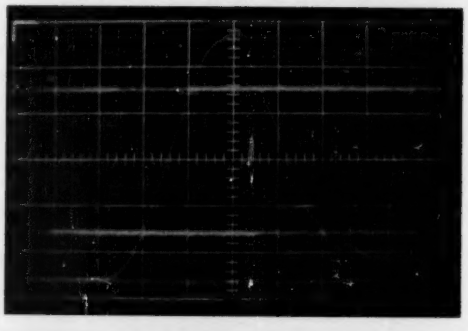
MACHINE screws are often required to withstand tensile or shear loads applied at rates ranging from hundreds to millions of pounds per second. Such load conditions are common in certain types of protective or safety devices which depend upon screw failure for successful performance. For these and other applications, variation of fracture load with loading rate is of practical significance in design.

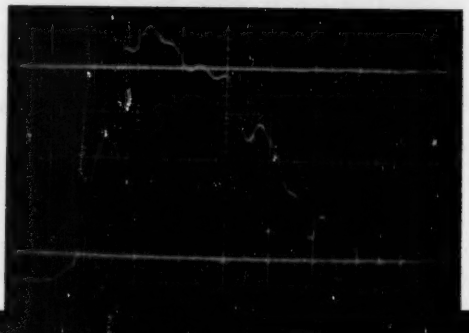
Tensile strength of many metals and alloys is known to increase significantly with an increasing rate of loading.[1] However, because of the complicated stress distribution in a threaded joint, this information can not be applied directly to predict the strength of screw-type fasteners. An experimental approach is usually required for evaluation of failure stress.

Some experimental investigations have been reported. Elongation and fracture energy of $\frac{3}{8}$ in. and larger bolts have been determined for both static and impact tensile tests.[2] In these tests, fracture energy increased with increasing load rate for bolts made of steel and brass. Strength values were not obtained for the impact tests. Static and impact fracture loads, however, have been reported for $\frac{3}{4}$ in. steel bolts where the high-rate loading consisted of repetitive blows.[3]

Results of an investigation of the tensile and shear strength of No. 10 machine screws at high-loading rates are reported here. In this testing program, maximum tensile loads were determined for loading rates ranging from approximately 15 to 3.5×10^6 lb per sec. Maximum shear loads were determined for rates from approximately 15 to 6×10^4 lb per sec. The highest rate is less than, but of the same order of magnitude as, that obtainable with a pendulum-type impact machine used for tension testing.







Test Apparatus: Four types of commercial screws were tested: 10-24 steel, 10-32 steel, 10-24 brass, and 10-32 brass. All had fillister heads and were $1\frac{1}{4}$ in. long. Thickness of the nuts was 0.125 − 0.005 in.,

[1]References are tabulated at end of article.

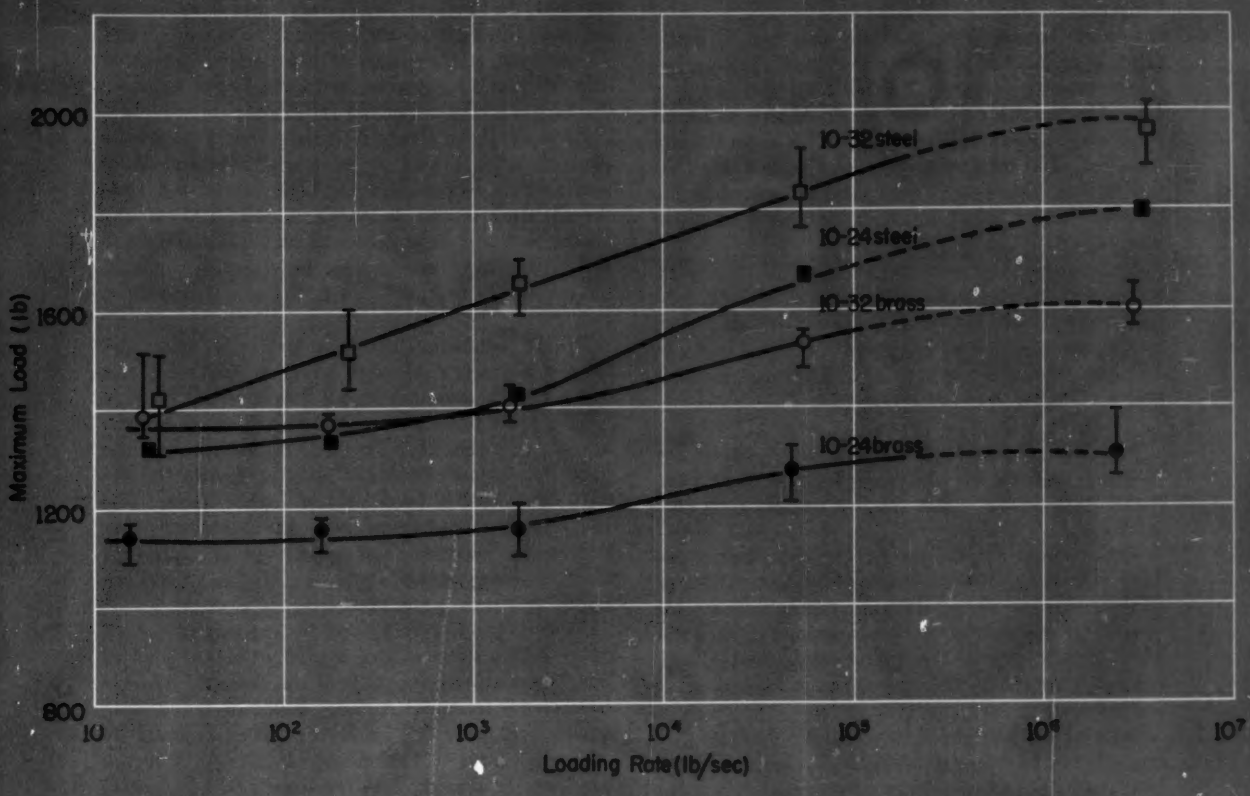


Fig. 1 — Above—Tensile-fracture loads for No. 10 machine screws at room temperature. Because of wide variations in test results, data scatter for 10-24 steel screws is not indicated for clarity.

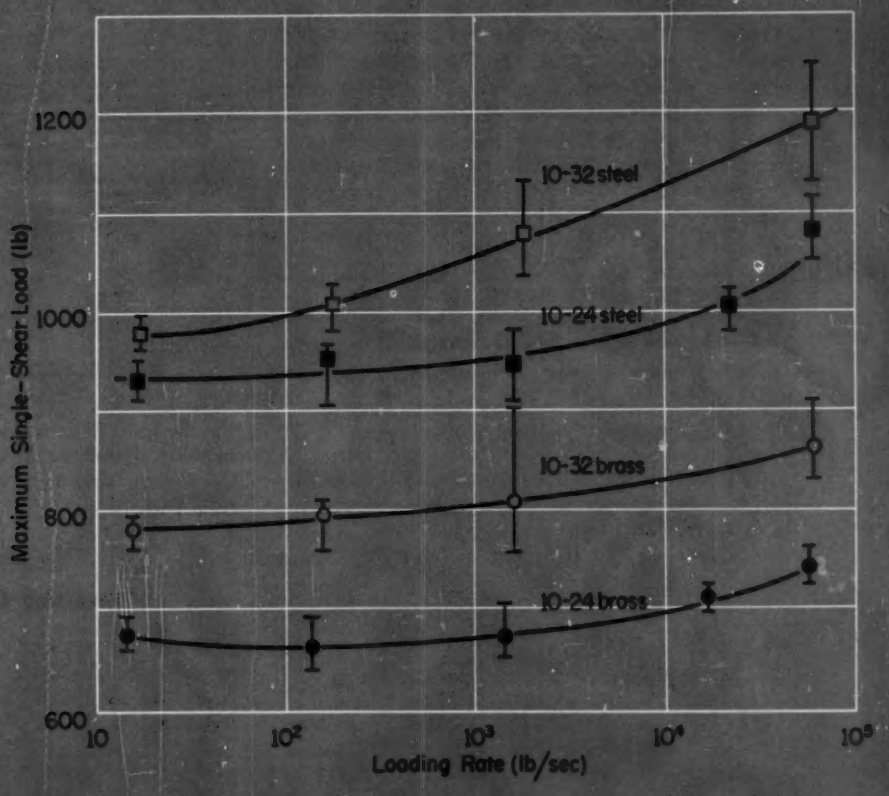


Fig. 2 — Right — Shear-fracture loads for No. 10 machine screws at room temperature.

except for the 10-32 brass nuts which were 0.120 – 0.010 in.

Special fixtures were used for the tests. Tensile grips were fabricated so that the gage distance between bearing surfaces of screw head and nut was 1 in. Double shear was used for shear tests although single-shear loads are reported. The shear fixture consisted of a stationary yoke and a movable central section. Screws and nuts were assembled in the fixtures "finger-tight" for both tests so that there was essentially no preloading.

An Instron tester and a pneumatically operated, high-speed tensile machine[4] were used. For the lowest crosshead velocities, load was indicated with a constant-paper-speed pen recorder. An oscilloscope and a camera were used to record load-time information for higher crosshead velocities.

Test Results: Average maximum-load curves for tension and shear are shown in Fig. 1 and 2. Data points are average values for five tests at each condition.

The vertical lines through the data points indicate the range of test readings at that condition. Dashed portions of tension-load curves indicate the average of the maximum loads estimated from individual load curves containing oscillations. Stripping of threads is believed to have caused these oscillations.

Both tensile and shear strength of these fasteners increased as loading rates increased. Strength of the steel screws exhibited a greater dependence upon the rate than did the strength of the brass screws. Comparison of load values for rates of 20 and 60,000 lb per sec shows that tensile loads for 10-24 and 10-32 steel screws increased 26 and 32 per cent, respectively, while shear loads increased 27 and 23 per cent. For 10-24 and 10-32 brass screws, the increase in tension was only 13 and 12 per cent, respectively. In shear, both screws showed an increase of 10 per cent.

Greatest differences were observed for tensile tests in which the lowest rates were near 20 lb per sec and the highest rates were near 3-million lb per sec. Strength of steel screws increased 37 and 43 per cent and strength of brass screws increased only 15 and 17 per cent, with the larger increases for each material being for 10-32 sizes.

Ratio of shear strength (single shear) to tensile strength, Fig. 1 and 2, is nearly independent of loading rate. This ratio for both coarse and fine-thread steel screws is approximately 0.70 at the lowest rate and only decreases to 0.65 at 60,000 lb per sec. The shear-tension ratio for both brass screws ranges from 0.56 to 0.59 for both rates.

Failure Characteristics: For the steel assemblies in tension, screw threads were stripped and nut threads were distorted at all loading rates.

The 10-24 brass screws fractured at random locations along the gage length. Appearance of the fractured surfaces indicated that no brittle failures were encountered even at the higher rates. The 10-32 brass screws failed both by thread stripping and screw fracture. The percentage of each type of failure was about equal for all rates, and no brittle fractures were observed.

Shear failures were similar in appearance for all screws. The shear planes tended to be oriented at the same angle as the pitch of the threads. Appearance of the fractured surfaces indicated that failure occurred with varying amounts of shear, followed by a brittle fracture. The extent of the brittle region increased as loading rate increased. Screw threads near the fracture locations were somewhat crushed.

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2. H. L. Whittemore, G. W. Nusbaum, and E. O. Seaquist—"Impact and Static Tensile Properties of Bolts," *Journal of Research*, National Bureau of Standards, Vol. 14, 1935, pp. 139-188.
3. H. M. Forkois, R. W. Conrad, and I. Vegniss—"Properties of Bolts Under Shock Loading," *Transactions of Society for Experimental Stress Analysis*, Vol. 10, No. 1, 1952, pp. 165-178.
4. R. E. Ely—"High-Speed Tensile Tests of Thermoplastics," *Plastics Technology*, Vol. 3, No. 11, 1957, p. 900.

Tips and Techniques

Estimating Frequency Responses

In estimating frequency responses, it is often useful to know the spread in the number of octaves, N, between two frequencies f_1 and f_2. The relationship is $N = 3.32 \log_{10} (f_2/f_1)$.—JESSE ROTH, *New York, N. Y.*

Solving Inverse Square Relationships

Here is a direct slide-rule method for solving problems which involve inverse-square relationships. To solve for R and x in the expression, $a/R_1^2 = N/R_2^2 = b/R^2$, set a on the B scale opposite R_1 on the D scale. The value of x is found on B scale opposite R_2 on the D scale. Value of R is read on the D scale opposite b on the B scale.—JESSE ROTH, *New York, N. Y.*

Converting Hardness Values

Converting Rockwell A, R_a, hardness values to approximate Rockwell C, R_c, equivalents can be easily accomplished with the following simple formula:

$$R_c = 2(R_a - 52)$$

—HAROLD SEDLIK, *Jacobs Mfg. Co., Hartford, Conn.*

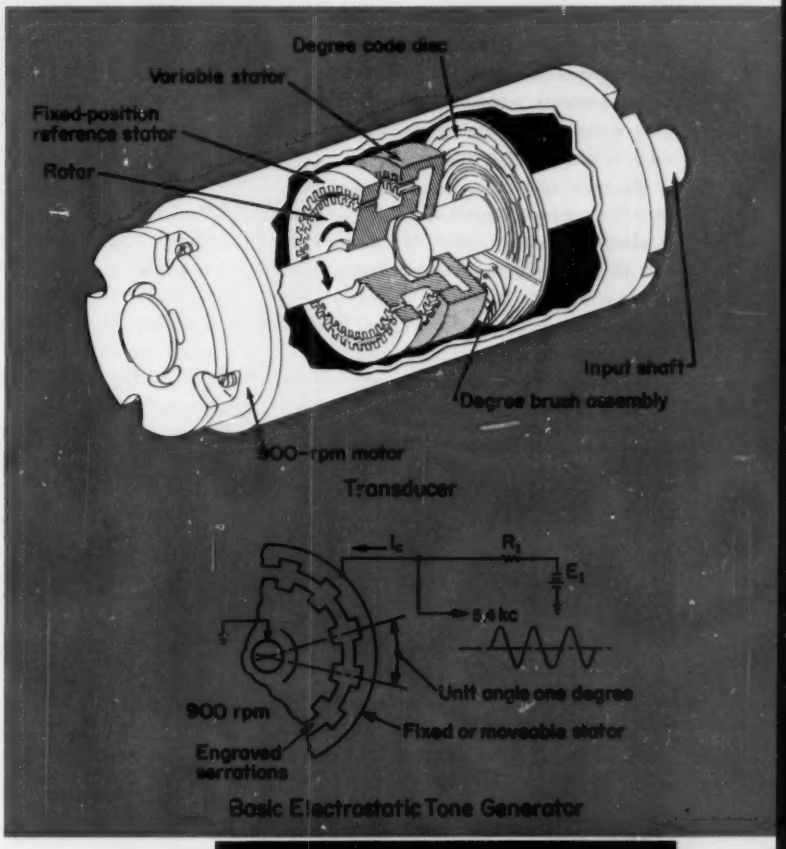
Signal Generator with Two Stators Measures Angles To 0.001-degree

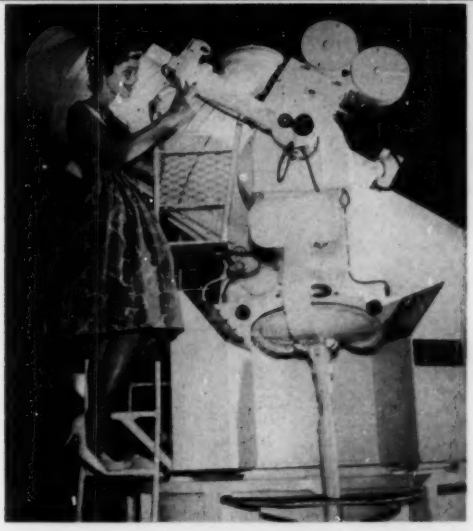
HIGH-RESOLUTION ANGLE ENCODER is designed around two rotating electrostatic signal generators. Developed for optical tracking instruments, the unit is sensitive to angular displacements of 0.001 degree (3.6 sec). This is the angle subtended by a ping-pong ball at a distance of 1 mile.

The heart of the encoder design is a pair of 2-in. diameter stator members which are concentric with a one-piece double rotor. Each of the stators are engraved with 360 serrations around their inner surfaces, and each end of the double rotor is constructed with a matching number of teeth around its periphery.

As the rotor turns, the capacitance between each stator ring and the rotor varies slightly as the serrations pass one another. A voltage applied across the air gap causes a charging current to flow into the rotor-stator variable "capacitor," generating an ac signal or tone.

The reference stator, held rigidly against the frame of the instrument, produces a 5.4-kc signal when rotor speed is 900 rpm. The second stator, mounted on the transducer input shaft, produces an identical 5.4-kc signal. This latter signal varies in phase with respect to the reference signal as the transducer input shaft is turned. Shaft rotation of 1 deg equals 360 electrical degrees of phase shift between the variable and reference phase signals.





ELECTRONIC PHASE-DETECTOR system senses the phase angle between the two 5.4-kc signals and converts it into decimal display.

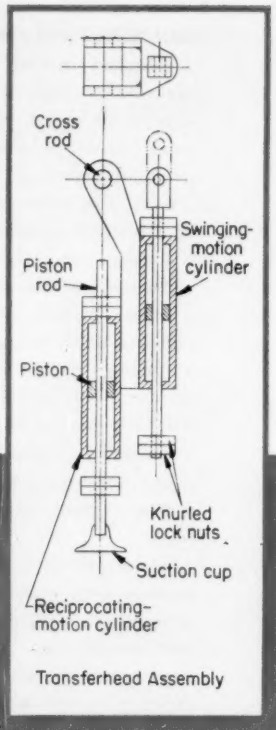
The system was developed jointly by the Ballistic Research Laboratories, the Norden Div. of United Aircraft Corp., and Colorado Research Corp. for optical tracking instruments such as the Space Probe Optical Recording Telescope shown.

Two Air Cylinders Produce

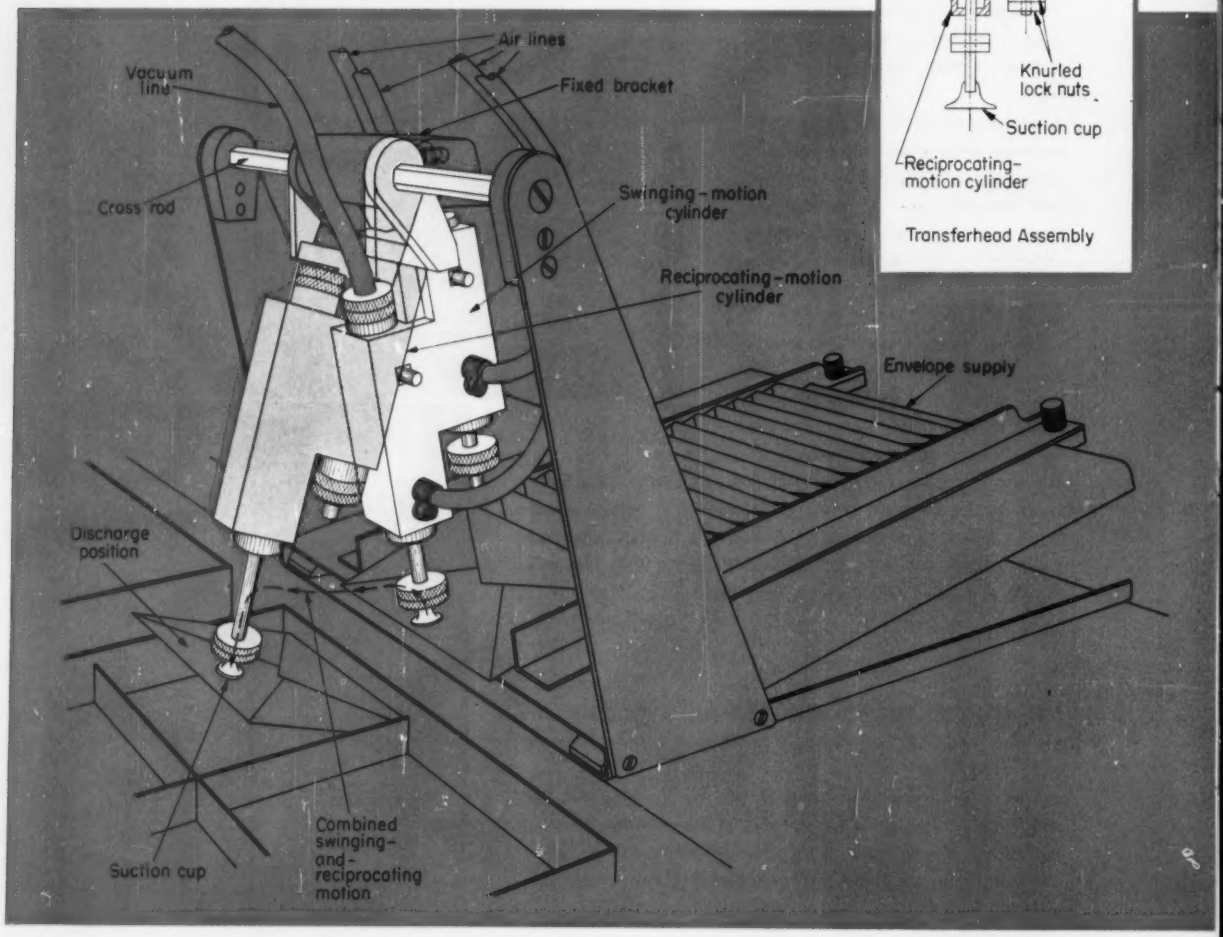
ACCURATE, HIGH-SPEED TRANSFER of flat paper objects is assured in a collator transfer head of simplified design. Operating power comes from two air cylinders integral with the transfer head assembly. One cylinder produces a swinging motion and the other a reciprocating motion.

The transfer head swings back and forth from a cross-rod support when air pressure is alternately introduced to the top or bottom of the swinging-motion cylinder. The upper end of the piston rod in this cylinder is secured in a slotted fixed bracket mounted to the cross rod. In operation, the "swinging cylinder" slides up and down on its piston rod.

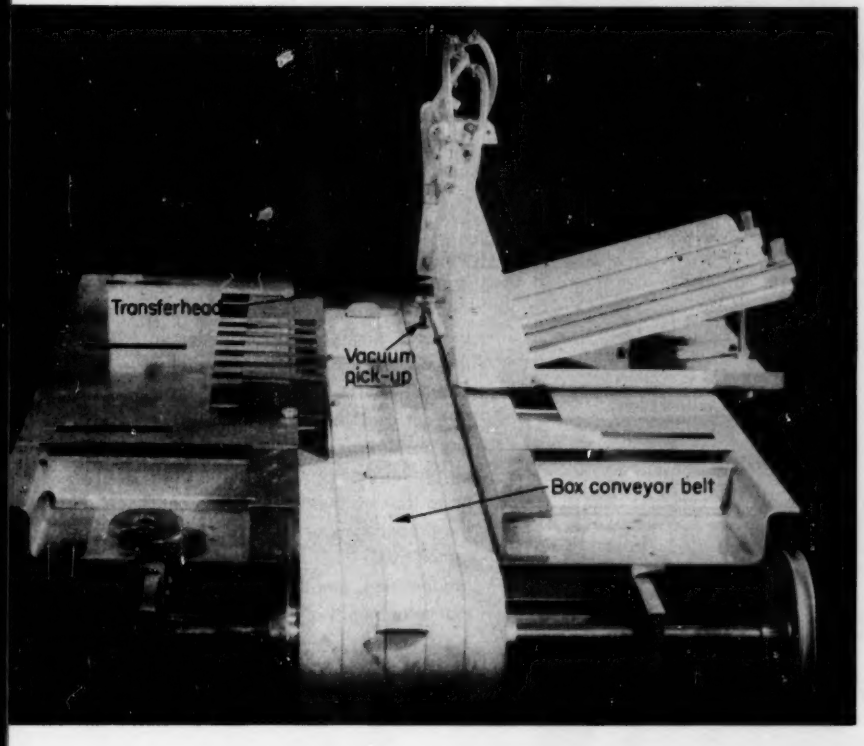
RECIPROCATING MOTION of the vacuum pick-up plunger takes place in the second integral cylinder. In-and-out movements of the piston rod in this cylinder is also by controlled sequencing air pressure to the top and bottom of the cylinder. The hollow piston rod in this cylinder has a rubber vacuum cup mounted on the end. When vacuum is applied to the cup, sheets of paper, envelopes, cards, etc., can be picked up and quickly swung to the discharge position. At this point, the vacuum is released and a blast of compressed air dislodges the material into the proper compartment in cardboard boxes on the machine's moving conveyor.



Transferhead Assembly



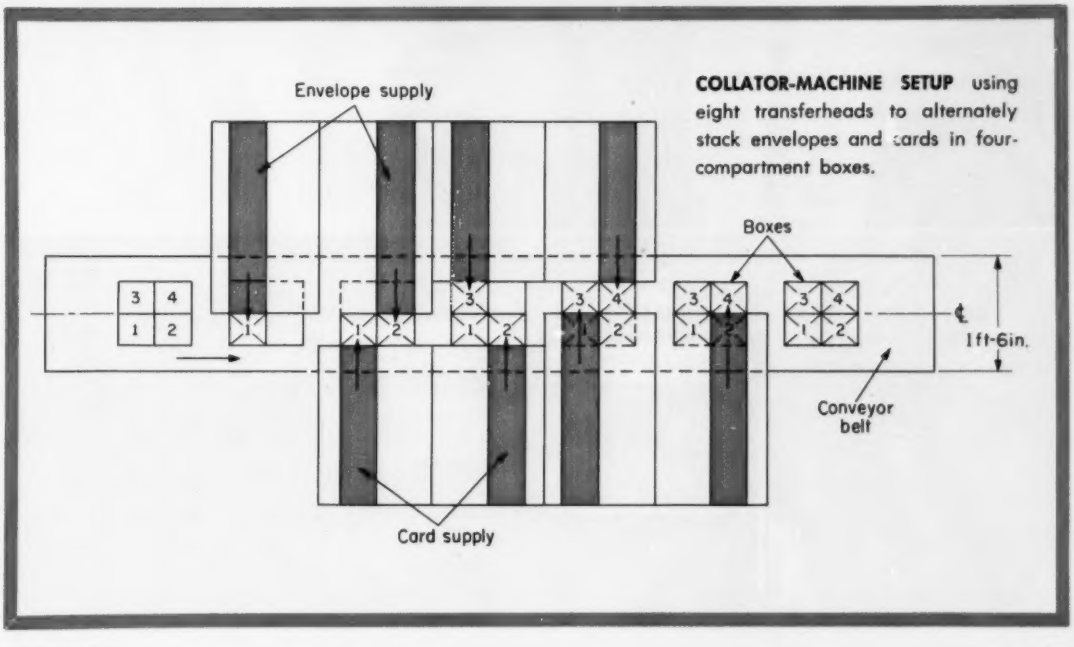
Swinging Up-and-Down Motion



CONVEYOR-ACTUATED SWITCHES and station interlocks operate electropneumatic valves which control, in proper sequence, the swinging and up-and-down motions of the plunger in each station transfer head.

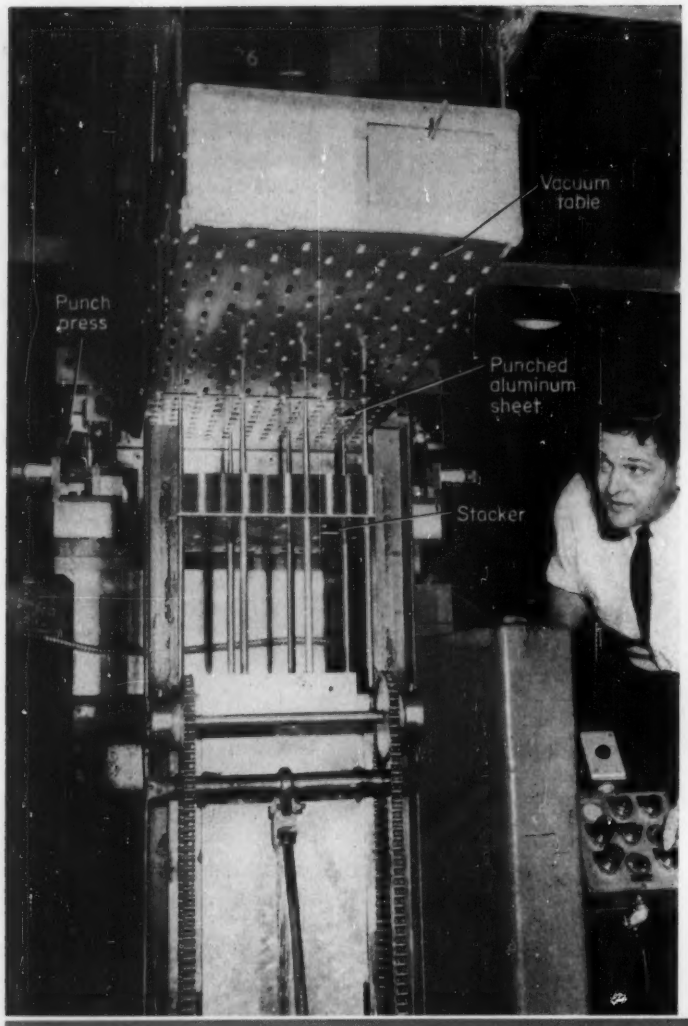
Position of knurled lock-nuts on the piston rods can be easily adjusted to change amount of swing and reciprocation of each plunger.

This collating machine was designed by Zuce Kogan Engineers, Chicago, Ill., to handle a variety of sizes, shapes, thicknesses, and weights of printed matter.



COLLATOR-MACHINE SETUP using eight transferheads to alternately stack envelopes and cards in four-compartment boxes.

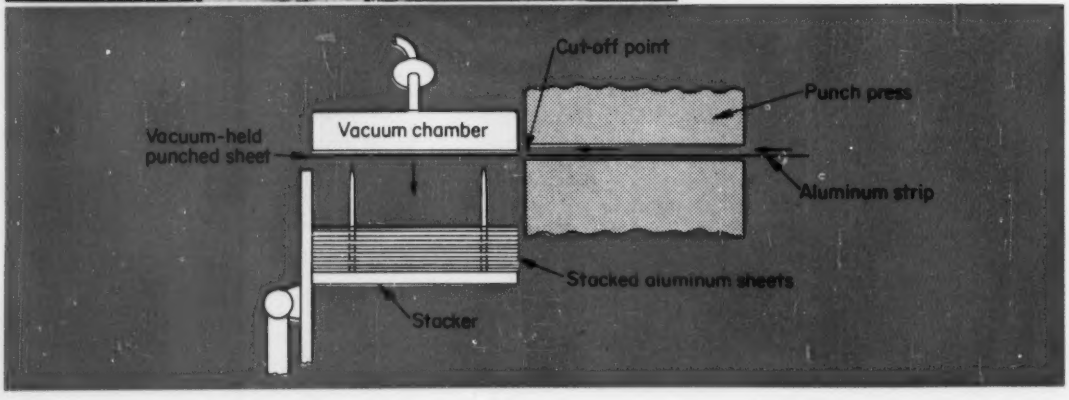
Suction Solves Metal-Stacking Problem



OVERHEAD VACUUM "TABLE" holds thin metal sheets flat as they are pushed from an automatic punch press. As reported by designer, Joseph J. Wilson of Westinghouse Electric Corp., Staunton, Va., the unit was designed to handle thin aluminum fins for heat exchangers.

After holes are punched, a length of the 7-mil thickness metal is pushed under the suction chamber. It remains flat as it slides out. A small, lengthwise groove is added between each column of holes in the flat sheets to increase rigidity.

When the desired length of fin is fed out completely and cut off, the fins are dropped by momentarily interrupting the vacuum. The fins fall on to tapered metal guide rods until the proper number pile up. A new set of guide rods are then indexed into position, and the machine automatically begins another cycle.



Recent experimental studies have uncovered significant facts about the vibration characteristics of rotor and support systems. Based on these findings, here's a new and practical approach for

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predicting critical speeds

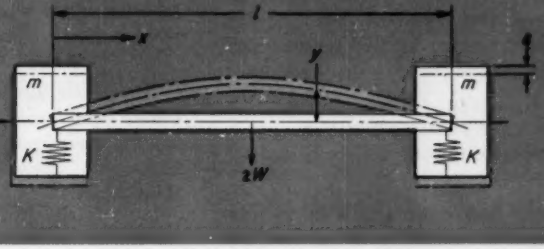


Fig. 1 — Equivalent elastic-support system for general analysis of critical speed conditions in rotating machine elements.

WHEN a potential critical-speed condition threatens safe operation of a machine design, modifications must be made to move the critical speed out of the danger zone or, at least, to reduce its intensity. Key problem is to predict critical speeds with sufficient accuracy to permit sound, reliable design judgments.

Present methods of critical-speed calculation are based on the assumption of a rigid support; that is, a support which does not contribute in any way to machine vibration at a critical-speed condition. The only vibrating element considered is the rotor.

In many instances, however, vibrations occur under conditions for which these methods and assumptions do not provide an adequate explanation. If vibration develops at a speed above the calculated critical value, the reason is usually attributed to gyroscopic effects or the stiffening influence of hub members. If vibration occurs at a speed below the calculated critical value, the approximate nature of the calculation or the effect of elasticity of the supports might be blamed.

This effect of the elasticity of the supports on the critical speed is well recognized. However, there is little agreement among responsible engineers on the relative importance of this effect. Some author-

ities[1,2] have held that practically all naval turbines have a critical speed in the running range, even though design was based on a critical speed 25 per cent above the maximum operating condition. Other authorities have pointed to a number of instances in which the observed critical speed was close to the calculated value.

To provide a basis for development of a general theory on rotor vibration that would reconcile the various contradictory—and often puzzling—factors, an experimental vibration study was conducted under controlled conditions. Details of the test method employed and sample calculations that illustrate application of the theoretical approach are reported in the accompanying section on *Experimental Vibration Study.*

Experimental Findings: Based on the results of this vibration study, an important conclusion can be drawn: A completely rigid support system is not possible. For certain combinations of resilience and vibration frequency, the supports may appear to be at rest, or nearly so. However, at a different frequency, the same supports vibrate violently.

Phase relationships between support and shaft movements did not seem to be clear until a plot of both movements at various low natural frequencies suggested that the movements of the support were in opposite phase to those of the shaft's center of gravity and not to its ends. Amplitude of the support movements decreased gradually with distance from the shaft center line.

Equivalent Mass Concept: These observations led to the concept of an "equivalent mass" for the support. This equivalent mass replaces the actual masses of all the supporting members that take part in the vibration and is defined by two fundamental relationships:

1. Kinetic energy of the equivalent mass equals the sum of the energies of the masses which it replaces.
2. Mobility of the equivalent mass is equal to the mobility of the support system.

Thus the vibration system of any rotating machine can be visualized as consisting of the continuous masses of the shaft-rotor assembly and the equivalent mass of the support, the whole system being free in space. Such a system, by the law of inertia, will maintain the position of center of gravity. If part of the system moves in one direction, other parts will move in such a way as to keep the combined center of gravity of shaft and supports at rest.

This concept is the basis of the method of vibration analysis presented in this article. However, one point must be kept in mind. The "equivalent mass" used here is a construction to fit the facts, not a physical reality.

Design Analysis: Normal objective of a vibration study is to determine exciting and resonant frequencies. In rotating mechanical assemblies, design interest centers mainly on the vibration characteristics of the rotor elements where the kinetic stresses due to vibration are superposed on those developed by centrifugal force. As a result, these elements require a closer check than the relatively low-stressed stator members.

A convenient equivalent system for this type of vibration study will focus on the rotor. Stator parts are considered only in terms of their relation to the rotor. Several possibilities are offered in the development of such a system. The one depicted in Fig. 1 has been selected for this analysis. It leads to conclusions which agree closely with the experimental study mentioned previously.

Basic Relationships: A general expression for dynamic behavior of the elastic system shown in Fig. 1 can be developed from the basic differential equation for a vibrating beam. This dimensionless expression is

$$\frac{q}{\frac{EIq^4}{K} - \frac{2W}{mgl}} = \frac{\tan\frac{ql}{2} + \tanh\frac{ql}{2}}{2} \qquad (1)$$

where q is given by

$$q = \left(\frac{2W\omega^2}{gEIl}\right)^{1/4} \qquad (2)$$

Equation 1 may be considered a characteristic equation of the elastic system for which it is valid. It also can serve as a practical tool for qualitative analysis of systems of more general form than that on which it is based.

In Equation 1, EI/K and $2W/(mgl)$ are parameters which characterize the supports. Term EI/K is the stiffness ratio of the system since EI is a meas-

Nomenclature

E = Modulus of elasticity, psi
f = Natural frequency of system, cps
I = Moment of inertia of shaft, in.^{4}
K = Spring modulus of support, lb per in.
l = Over-all length of shaft, in.
m = Equivalent mass of one support, lb-sec^2 per in.
m_1 = Mass of rotor and shaft assembly, lb-sec^2 per in. $= 2W/g$
q = Frequency factor (Equation 2)
W = Weight of one-half of shaft, lb
w = Equivalent weight of stator parts, lb $= mg$
x = Variable distance from left end to a point on the axis of the shaft, in.
y = Maximum elastic deflection of a point on the axis of the shaft, in.
ω = Any natural frequency of the system, radians per sec
ω_n = Natural frequency of system with rigid supports, radians per sec
δ = Displacement of equivalent mass, in.

[1]References are tabulated at end of article.

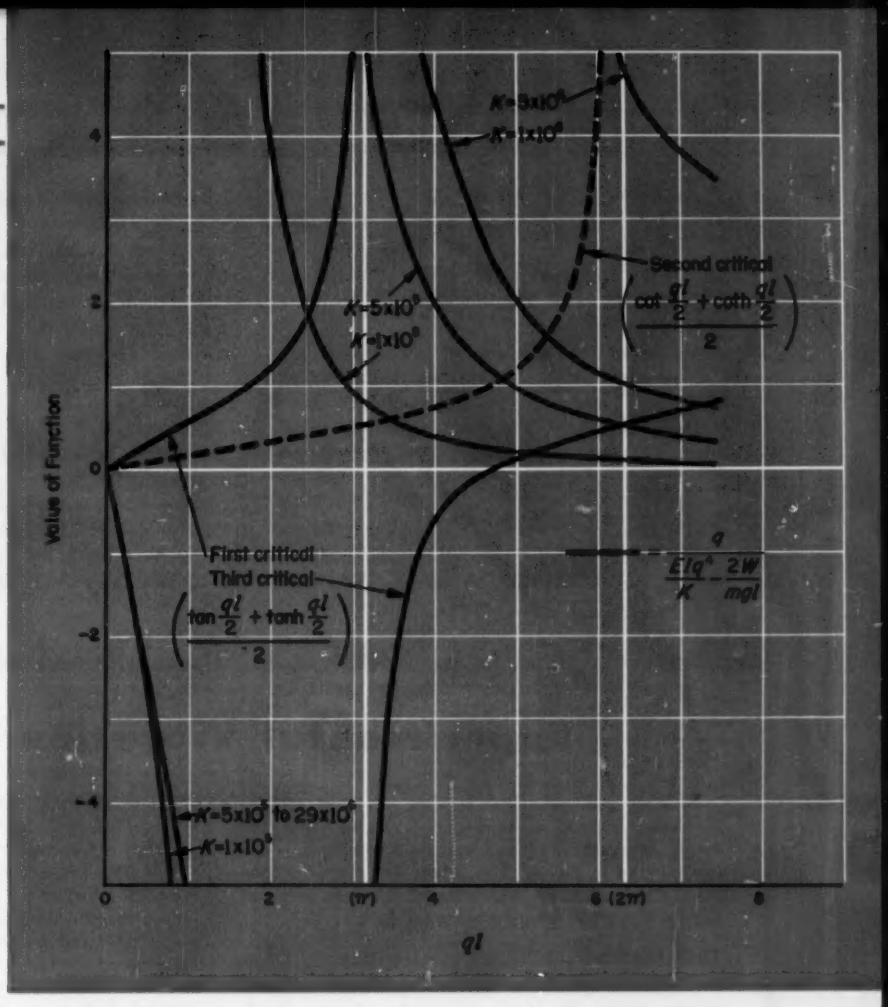


Fig. 2—Graphical solution of characteristic equation for elastic system shown in Fig. 1. First and third critical speed curves are plots of the right-hand side of Equation 1 while curve for second critical speed pertains to antisymmetrical modes of vibration. Parametric curves for different values of spring modulus K are plots of the left-hand side of Equation 1. Intersections of the two sets of curve plots define possible critical speed conditions.

ure of shaft stiffness and K is a measure of the stiffness of the supports. Value of K can be found by measuring actual journal deflection under load. This measurement must be made when the machine is operating at or near normal speed to account for the effect of the variable resilience of the oil cushion in the bearings.

Similarly, term $2W/(mgl)$ is the mass ratio of the system; $2W/g$ is the mass of the shaft and m is the equivalent mass of the support. A direct approach for determination of m has not yet been found. For a given machine, Equation 1 can be used to solve for $2W/(mgl)$ if values are known for either: 1. K and one critical speed. 2. Two critical speeds.

Equation 1 provides an expression for determination of the natural frequencies ω of the elastic system through frequency factor q (Equation 2). However, q cannot be evaluated directly. A graphical method of solution will be used instead, following the approach proposed by Tobias and Fishwick.[3] This construction is shown in Fig. 2.

In this chart, right and left-hand sides of Equation 1 are plotted separately. The right-hand side of this equation is represented by the two tangent-like curve plots for first and third critical speeds. These plots are independent of the particular dy-

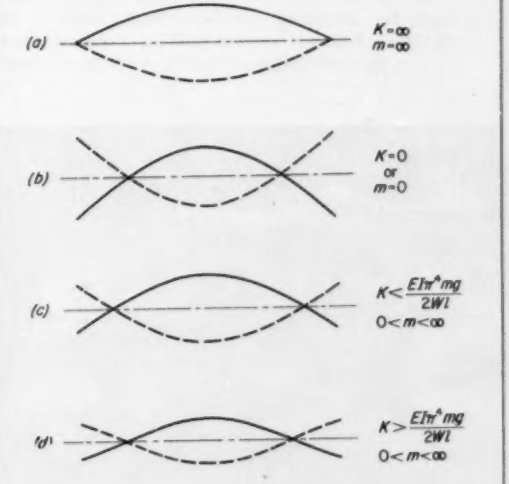


Fig. 3—Deflection curves for varying conditions of support stiffness in the elastic system in Fig. 1.

namic characteristics of the system.

The left-hand side of Equation 1 appears as a family of parametric curves for which EI/K and $2W/(mgl)$ are the parameters. These plots correspond to values of K ranging from 1×10^5 to 5×10^6 lb per in.

Intersections of the two sets of curve plots represent a solution for q for the particular system characteristics. Thus, each intersection indicates a critical speed condition. Multiple intersections along one parametric curve indicate several possible critical speeds.

System Behavior: Effect of different conditions of support stiffness and mass on vibration characteristics of the elastic system can be readily studied by substituting appropriate values for the parameters in Equation 1.

Five conditions, which are of particular significance in design, will be considered here.

1. For $K = \infty$ and $m = \infty$, Equation 1 gives the double solution, $ql = \pi, 3\pi$. From Equation 2, corresponding solutions are

$$\omega = \frac{\pi^2}{l}\left(\frac{EIg}{2Wl}\right)^{1/2}, \frac{9\pi^2}{l}\left(\frac{EIg}{2Wl}\right)^{1/2} \qquad (3)$$

As would be expected, this equation is the basic expression for the first and third natural frequencies of a uniform-section beam on rigid supports.[4] Deflection curve for this support condition is shown in Fig. 3*a*.

2. For $K = 0$ or $m = 0$, Equation 1 gives the

Experimental Vibration Study

To study the vibrational behavior of actual complex shaft-rotor systems, an experimental rig was built and tested under simplified and controlled conditions. This rig is shown in Fig. *a*. Test details and sample calculations, which illustrate application of the principles covered in the article text, are presented here.

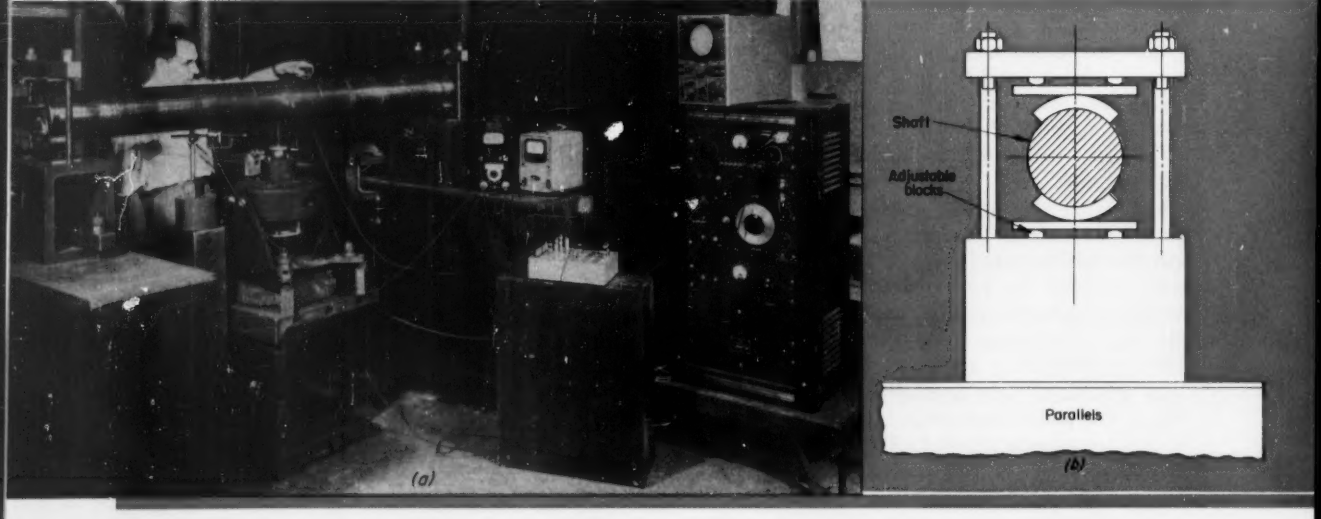
Test Method . . .

The critical speed of a machine represents a frequency of natural vibration of the rotor under operating conditions. This frequency will be different from the static natural frequency of the rotor due to various effects of rotation. The difference, however, is small and is commonly ignored.

The test rig, Fig. *a*, consisted essentially of a uniform round bar resting on two heavy beams, each of which was 36 in. high and weighed 3400 lb. Details of the bar-support assembly are shown in Fig. *b*. Distance between blocks could be altered to simulate varying degrees of bearing flexibility. All parts of the supports were clamped or bolted solidly together and to the floor.

The bar was excited by an electromagnetic shaker (nominal rating 50 lb) through a thin, flexible rod of adjustable length. This rod was fastened at one end to the shaker table and at the other end to the test bar. The shaker stood vertically under the test bar on several layers of rubber pads. Exciting frequencies were read from an oscillator dial on the shaker's power-supply cabinet. Excited frequencies, which are not always the same as the exciting ones, were determined by a contact pick-up connected to a sound level meter and a frequency analyzer.

Deflections of the bar or of the supports were measured by a vibration meter with a special high-sensitivity, velocity-type pick-up. These readings could be used to determine the modes. However, it was difficult to get clear readings because the pick-up, if held by hand, was not



double solution, $ql = 0, 4.70$. From Equation 2, neglecting the trivial solution, $\omega = 0$,

$$\omega = \frac{22.1}{l}\left(\frac{EIg}{2Wl}\right)^{1/2} \quad (4)$$

As would be expected again, this equation is the basic expression for natural frequency of a beam with free ends. Deflection curve for this condition appears in Fig. 3*b*.

3. When $m < \infty$ and

$$K < \frac{EI\pi^4 mg}{2Wl}$$

intersection of the parametric curves with both curve plots for the right-hand side of Equation 1 are real (see Fig. 2). For this support condition, values of both first and third natural frequencies are less than those for a beam with rigid supports and greater than those for a beam with free ends. Corresponding deflection curve is shown in Fig. 3c.

4. When $m < \infty$ and

$$K > \frac{EI\pi^4 mg}{2Wl}$$

intersections of the parametric curves with the left "branch" (first critical speed) of the curve plots for the right-hand side of Equation 2 become imaginary (see Fig. 2). The smallest real solution for natural frequency will be greater than that for the beam with rigid supports. Thus, natural frequencies greater than those calculated for the rigid-support arrangement are not impossible if the proper

steady enough or, if supported on a stand, received frequencies from unknown sources elsewhere in the system.

A more convenient technique for determination of the modes employed a stationary pick-up, at point of excitation, connected to the X-axis control circuit of an oscilloscope. Another pick-up, on the scope Y-axis, was moved along the bar by hand. The resulting Lissajous figures gave an excellent comparative picture of the vibration conditions on the bar and on the supports.

Sample Calculations . . .

In one of the tests performed in this experimental study, spring modulus K for the bearing arrangement was determined statically as the ratio of one-half the weight of the bar to the bearing deflection. This result was considered satisfactory since the support bearings in the rig were not lubricated.

Observed natural (cyclic) frequency f of the steel test bar was 29 cps. Corresponding bearing deflection was $\delta = 0.012$ in. Other test-bar data were: $W = 390$ lb, $I = 101.9$ in.^{4} and $l = 84$ in. Thus, $K = 390/0.012 = 32{,}500$ lb per in.

As a preliminary step, equivalent mass mg of the support must be determined. By definition, $\omega_n = 2\pi f = 184$ radians per sec. From Equation 2,

$$q = \left[\frac{2(390)(184)^2}{384(29)(10)^6(101.9)(84)}\right]^{1/4} = 0.022$$

and $ql = 0.022(84) = 1.848$.

From Equation 1, then,

$$\frac{q}{\frac{EIq^4}{K} - \frac{2W}{mql}} = \frac{1.3238 + 0.7278}{2} = 1.0258$$

Substituting values for E, I, K, q, W, g, and l and solving gives $mg = w = 2480$ lb. Note that this value of equivalent mass is less than the actual weight of each support (3400 lb).

Actual critical speeds (resonant frequencies) can now be determined for any condition of stiffness of the support with this value of equivalent mass. For example, assume $K = 390/0.003 = 130{,}000$ lb per in. Corresponding parametric curve (Fig. 2) for this condition can be determined by calculating four points, such as $\omega_1 = 300$, $\omega_2 = 400$, $\omega_3 = 500$, and $\omega_4 = 600$ radians per sec.

For the first point ($\omega_1 = 300$ radians per sec) value of q_1 can be determined from Equation 2 as

$$q_1 = \left[\frac{2(390)(300)^2}{(384)(29)(10)^6(101.9)(84)}\right]^{1/4} = 0.0292$$

which gives $q_1 l = 2.458$. If left-hand side of Equation 1 is designated by X, then

$$X_1 = \frac{0.0292}{\frac{29(10)^6(101.9)(0.0292)^4}{(130{,}000)} - \frac{2(390)}{2480(84)}} = 2.288$$

Corresponding values for the other points can be determined in the same way. At point 2($\omega_2 = 400$ radians per sec), $q_2 = 0.0337$, $q_2 l = 2.838$, and $X_2 = 1.317$. At point 3($\omega_3 = 500$ radians per sec), $q_3 = 0.0377$, $q_3 l = 3.166$, and $X_3 = 0.894$. At point 4($\omega_4 = 600$ radians per sec), $q_4 = 0.0413$, $q_4 l = 3.47$, and $X_4 = 0.664$.

If these four points are plotted on the chart in Fig. 2 and connected by a smooth curve, this curve will intersect the first critical speed curve at $ql = 2.52$ and the second critical speed curve at $ql = 3.56$.

Thus, for the first critical speed condition, $q_{cr1} = 2.52/84 = 0.0300$. From Equation 2, $\omega_{cr1} = 316$ radians per sec which gives $f_{cr1} = 50.3$ cps.

For the second critical speed condition, $q_{cr2} = 3.56/84 = 0.0424$, $\omega_{cr2} = 664$ radians per sec, and $f_{cr2} = 105.6$ cps.

Experimental values for these first and second critical frequencies, determined on the test rig, were 52 and 112 cps, respectively. These values are much closer than would be expected for a rigid-support condition in which the critical speed ratio (first to second) is 1:4. Calculated first critical frequency for the rigid-support condition is $f_n = 77.7$ cps.

high stiffness-mass ratio can be achieved in the supports. Generally, natural frequency will increase when support mass m is reduced, if all other factors remain unchanged. Deflection curve for this support condition is shown in Fig. 3*d*.

5. When weight W of the rotor is increased without a simultaneous increase in its moment of inertia I, the effect is the same as reducing equivalent support mass m. In Fig. 2, parametric curves have been plotted for four values of K, ranging from 1×10^5 to 5×10^6 lb per in. These plots are based on $2W/(mgl) = 0.0025$.

The plot for $K = 1 \times 10^5$ lb-in. is representative of a considerable number of turbine designs. It intersects the first critical speed curve at $ql = 2.45$. Comparable value for a rigid-support arrangement is $ql = \pi$. Thus, from the general relationship established by Equation 2,

$$\frac{\omega}{\omega_\infty} = \left[\frac{ql}{(ql)_\infty}\right]^2 = \left(\frac{2.45}{\pi}\right)^2 = 0.61$$

Thus, natural frequency of the system is little more than half the critical frequency calculated for the rigid-support condition.

Value of K must be increased to 5×10^5 lb-in. to give $ql/\pi = 1$. At this combination of support stiffness and mass ratio, the natural frequency of the system will be about equal to the calculated critical speed for rigid supports, Equation 3. But this value of K represents a stiffness which is not normally found in turbine design, although it may exist in some types of compressors. For values of K larger than 5×10^5, up to the limit value of 29×10^6 lb-in., ω will be greater than ω_∞ but only by a small amount.

Second Critical Speed: Up to this point, all but one of the curves in Fig. 2 have been examined. The remaining plot (dotted line) represents the function

$$\frac{-\cot\frac{ql}{2} + \coth\frac{ql}{2}}{2}$$

This expression pertains to the antisymmetric modes of vibration. Each intersection of a parametric curve with this curve plot indicates a possible critical speed, corresponding to the second mode of the natural frequency for the elastic system. As shown by Fig. 2, this second critical speed decreases as K decreases for a given value of ω.

For $K = 1 \times 10^5$ lb per in. and $2W/(mgl) = 0.0025$, Fig. 2, the value of the second critical speed is nearly the same as the calculated first critical speed for the rigid-support condition, $ql = \pi$. This similarity of values can be misleading in design analysis unless shaft amplitudes and phase relationships are carefully checked. The true first critical-speed condition of the system will occur at a lower speed with correspondingly reduced intensity of vibration. If this condition is not recognized, it may be relegated to the category of secondary unexplained disturbances or, with other factors in combination, may be diagnosed as "oil-whip" or, perhaps, even "hysteresis-whip."

Oil-Whip Analysis: Equation 1 is a characteristic expression for all possible elastic modes of the rotor, regardless of the origin of the exciting frequency. Thus, it will account for the type of oil whip considered by Newkirk, Taylor, and Grobel[5, 6] where the shaft is the main vibrating element and the exciting frequency is produced by shaft precession inside the oil space of the journal. However, it will not be of help in the treatment of the Hummel-Hagg type of oil-whip[7] in which the oil cushion is considered as a quasielastic member and shaft elasticity is disregarded.

Elastic Line: When q has been determined, maximum deflection y can be readily calculated to establish the elastic line of the shaft. The elastic lines shown in Fig. 4 were developed from calculated data for the test bar described in *Experimental Vibration Study*. These shapes, which illustrate the effect of varying support stiffness while mass ratio is held constant, have been verified under controlled tests and confirm the validity of the mathematical derivations.

The shape of the elastic line commonly associated with the first critical speed for the rigid-support condition is of particular interest. This "single-belly" shape leads to the elastic line depicted in Fig. 4c for $K = 5 \times 10^5$ lb per in. and natural frequency $\omega < \omega_\infty$. As K and, therefore, W increase so that $\omega > \omega_\infty$, a node forms in the elastic line inside the bearings, Fig. 4*d*. As ω increases further, the node moves away from the bearings, and the elastic line approaches the shape associated with a third node.

Thus, combinations of K (or EI/K) and W/w to give $ql = \pi$ can be found in which neither K nor W is infinite. If a machine embodies such a combination, the observed frequency of the critical speed will be close to the calculated value for rigid supports, despite the actual flexibility of the support arrangement. As a general rule, however, $ql < \pi$ and the actual critical speed is less than that for the rigid-support condition. Amount of critical-speed depression depends upon the values of both K and W/w.

Support Motion: For the type of elastic system under consideration here, Fig. 1, motions of the supports are not identical with those of the ends of the shaft. Relative support-displacement characteristics for varying conditions of support stiffness are illustrated in Fig. 4. As the sketches indicate, support motion decreases as K increases. Under no condition, however, are the supports ever at rest during resonant rotor vibration. This characteristic holds true even when $ql = \pi$, although the shaft ends are motionless for this condition. Thus, the mathematical

analysis bears out the earlier conclusion that a completely rigid support is not possible. Consequently, if a vibration pick-up is fastened to the bearing brackets of a rotating machine, it will sense only the vibrational motions of the supports and does not provide a reliable basis for direct conclusions on dynamic shaft behavior.

Practical Application: For the foregoing theory to be of value in design calculations, K and m must be known. At present, calculation of these parameters directly from design dimensions is not practical. However, experience indicates that K and $W/(mg)$ can be regarded as characteristic constants for a given type of machine.

All values of K encountered so far by the author have been between the limits of 5×10^5 and 3×10^6 lb per in. The lower values are representative of single-stage turbines. Corresponding range for W/w is 0.22 to 0.25 with single-stage turbines at the high end of the range. Warner[1] has estimated a similar W/w as 0.2. However, the w used in this instance represents the actual weight of the stator parts, not the equivalent weight.

A catalog of values of K and W/w for a limited number of support designs has been started. When completed, it will furnish sufficient information to permit a close estimate of these parameters for all conventional types of turbines and compressors. This type of approach may offer possibilities in other design areas where accurate critical speed analysis is a problem.

If K and W/w are known, or can be assumed with sufficient accuracy, actual critical speeds can be computed by the following procedure:

1. Calculate the critical speed for the rigid-support condition by conventional methods, or from Equation 3.
2. Calculate the value of I_∞ from

$$I_\infty = \frac{4N_\infty^2 l^3 W}{Eg} \tag{5}$$

where N_∞ is the critical speed for the rigid support condition in revolutions per sec and is given by $N_\infty = \omega_\infty/2\pi$.

3. Draw a parametric curve in Fig. 2 for

$$\frac{q}{\frac{EI_\infty q^4}{K} - \frac{2W}{wl}}$$

with $q = ql/l$ as the variable. Where this curve intersects the tangent critical-speed curve find corresponding value of ql and calculate q. Actual critical speed can then be determined from

$$\omega = q^2 \left(\frac{EI_\infty lg}{W} \right)^{1/2} \tag{6}$$

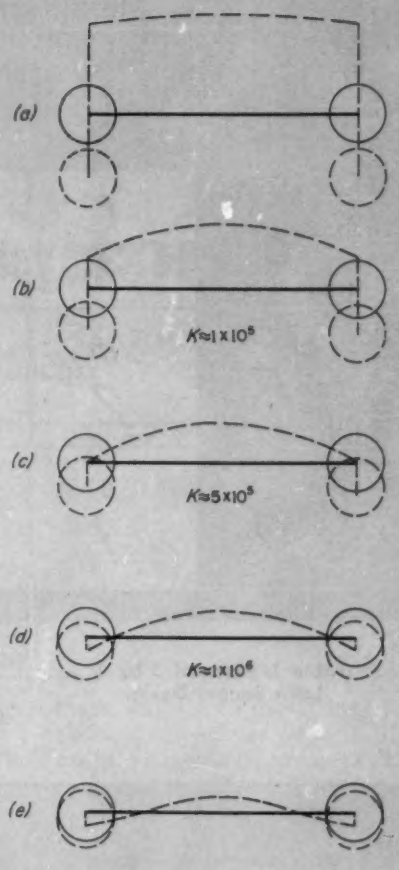


Fig. 4—Typical motions of vibrating rotor and stator masses for varying conditions of support stiffness in the elastic system shown in Fig. 1. Shape of elastic line at *a* corresponds to very low value of *K*. As *K* increases, elastic line forms "single belly" shape, *c*, and then develops nodes inside the bearings, *d*. At very high values of K, elastic line approaches shape associated with a third node, *e*.

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Setting up and interpreting

Hole Size \ Metal Hardness	I	II	III
U	f 4	s 1	m 2
P	m 2	f 3	s 2
O	s 1	m 2	f 4

Table 1—Typical 3 by 3 Latin Square Design

AS THE number of variable factors introduced in an experiment increase, the complexity of the experimental setup and interpretation compounds itself. A clear-cut method of coping with these multiple-factor experiments with a minimum of testing and data analysis is pinpointed in this concluding article of a two-part series.

As with the first part of this series, which dealt with single-factor experiments, this article is based on a sound statistical approach. Part 1 appeared on Page 134 of the June 11 issue of MACHINE DESIGN.

After the basic analysis tool, the Latin square, is introduced, two multiple-factor experiments are analyzed.

Table 2—Analysis of Latin-Square Columns and Rows in Table 1

	Columns			Σ Rows	(Σ Rows²)
Rows	4	1	2	7	49
	2	3	2	7	49
	1	2	4	7	49
Σ Columns	7	6	8	$\alpha = 21$	$\beta = 147$
(Σ Columns²)	49	36	64	$\gamma = 149$	

Latin Squares

Simultaneous evaluation of the effects of several factors or variables to obtain optimum information

Table 3—Analysis of Latin-Square Entries in Table 1

	Entries			
	f	m	s	
	4	2	1	
	3	2	1	
	4	2	2	
Σ Entries	11	6	4	Total
(Σ Entries²)	121	36	16	$\tau = 173$

Table 4—Squares of Values in Latin Square in Table 1

	Columns			
Rows	16	1	4	
	4	9	4	
	1	4	16	Total
Sum	21	14	24	$\xi = 59$

ENGINEERING EXPERIMENTS

Part 2 — Multiple-Factor Experiments

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with a minimum number of experimental runs can be accomplished with the Latin square. A square divided into rows and columns of squares, the Latin square got its name from mathematician Leonhard Euler who labeled the component cells of the large square with Latin letters.

The solution of a typical problem with a Latin square can best describe its practical application. Suppose, for example, excessive leaf-spring breakage is occurring on a snap-action switch. Fracture occurs at a stress-relief hole in the spring after several thousand operations. It is suspected that normal variations in metal hardness might be contributing to the problem along with rate of switch actuation. It is theorized that a variation in stress-relief hole size may improve the life characteristics.

Springs are sorted for hardness and grouped into three categories—I, II, and III. Three rates of actuation (*f*, *m*, and *s*) are selected for the test. Holes are punched and sorted into three categories: 1. Oversized hole, *o*. 2. Undersized hole, *u*. 3. Optimum hole size, *p*. The test is to determine whether actuation rate, hole size, or spring hardness is significant in contributing to breakage. The experiment is laid out as a 3 by 3 Latin-square design, Table 1. The rows correspond to hole size and the columns to metal hardness. Entries in Table 1 correspond to rates of actuation—*f*, *m*, or *s*.

The table is programmed in randomized blocks, so that rates of actuation—*f*, *m*, and *s*—occur once and only once in each column and row. Numbers in the body of Table 1 are the frequency of spring breakage out of 10 samples after 50,000 operations on a standard test fixture.

A Latin-square experiment with N columns and N rows requires N^2 runs. A full-factorial experiment on the other hand, would require N^3 runs. Therefore, the Latin square comprises $1/N$th as many

Table 5—Steps for Calculating Variance, F, for Latin Square in Table 1

	Sum of Squares, S		Degrees of Freedom, D		Mean Square, M		Variance Ratio, F	
Columns	$\frac{\gamma}{N} - \frac{a^2}{N^2}$	0.666	$D_C = N - 1$	2	$M_C = \frac{S_C}{D_C}$	0.333	$F_C = \frac{M_C}{M_X}$	1.0
Rows	$\frac{\beta}{N} - \frac{a^2}{N^2}$	0.000	$D_R = N - 1$	2	$M_R = \frac{S_R}{D_R}$	0.000	$F_R = \frac{M_R}{M_X}$	0.0
Entries	$\frac{\tau}{N} - \frac{a^2}{N^2}$	8.666	$D_E = N - 1$	2	$M_E = \frac{S_E}{D_E}$	4.333	$F_E = \frac{M_E}{M_X}$	13.0
Residual	$\epsilon + \frac{2a^2}{N^2} - \left(\frac{\gamma + \beta + \tau}{N}\right)$	0.667	$D_X = N^2 - 3N + 2$	2	$M_X = \frac{S_X}{D_X}$	0.333	—	—

runs as the full-factorial experiment, a considerable saving particularly when the square is large.

The solution of an N by N Latin square proceeds as follows: Individual readings, in this case frequency of breakage, are transcribed into Tables 2, 3, 4, and 5 and the noted operations performed. Thus, in Table 2, obtain the sum for each row, square these sums, and total the squares as shown to obtain β. In the same table is the total of all observations, α. Obtain the sum for each column, square these sums and total the squares to obtain γ. In Table 3 obtain the sum for each type of entry, in this case actuation rate f, m, and s, square these sums, and total these squares to obtain τ. In Table 4, enter the square of each individual observation and add to obtain ϵ.

Transcribe the values of α, β, γ, ϵ, and τ into the formulas in Table 5 to obtain sum of squares, S. Values of the mean square, M, for columns, rows, entries, and residual are obtained by dividing sum of squares, S, by degrees of freedom taken from the previous column in Table 5.

The variance ratio for columns is obtained by dividing the mean square value for columns by the mean square value for the residual. The same procedure applies to rows and entries. Variance occurring in columns, rows, and entries is significant at the 95 per cent confidence level if the variance ratio exceeds the value shown in Table 4 for the size of Latin square used. Thus, in a 3 by 3 Latin square, the variance ratio for columns, rows, or entries must exceed 19.2 to be significant. There is only a 5 per cent possibility of a variance ratio of 19.2 occurring as the result of chance.

In the spring-breakage problem, a maximum variance ratio, F, of 13.0 occurs for actuation rate. Data in Table 6 indicate that variance ratio must exceed 19.2 to be significant at the 95 per cent confidence level and 9.0 at the 90 per cent level. Therefore, we are better than 90 per cent confident, but less than 95 per cent confident that spring breakage is related to actuation rate and is not the result of chance. The other factors, metal hardness and hole size, are shown to be completely insignificant.

Caution must be exercised in setting up and interpreting the results obtained from a Latin-square experiment if the three variables making up the columns, rows, and entries are not completely independent of one another. If interactions occur between independent variables, a false conclusion may be drawn from the experiment. The Latin square is commonly used, however, as an exploratory experimental design for finding ranges of variables to be studied by more precise methods. For this purpose it is a highly useful experimental design tool.

The 3 by 3 Latin square illustrated here is inadequate for most experimental applications, but was used as a simple demonstration of techniques for purposes of this article. Latin squares in the 4 by 4 and 5 by 5 sizes are more commonly used. Improved accuracy obtained by a larger square is quite evident in Table 6 which shows the decrease in variance ratio associated with squares of increasing size. The identical steps used in solving the simple 3 by 3 Latin square are directly applicable to the larger squares.

Table 6—Variance Ratios, F, for an N by N Latin Square

N	For Confidence Level of 90 per cent	95 per cent	99 per cent
3	9.0	19.2	99.0
4	3.3	4.8	9.8
5	2.5	3.3	5.4
6	2.2	2.7	4.1
7	2.0	2.4	3.5
8	1.9	2.2	3.2

Multiple-Factor Analysis

The classical approach to experimentation is to hold constant all independent variables except the one being investigated. This is difficult to do in many engineering experiments and, in fact, is not the best approach. A more accurate picture of the experimental results can be obtained when one variable is changed by allowing others to vary throughout their normal range. In this way the influence or interaction of one variable on another can be detected.

The multiple-factor experiment permits this type of analysis and is probably best described by its direct application to a typical problem. A three-factor experiment each at N levels will be used for illustration. Higher factorial experiments are solved in a like manner, but are considerably more complex. The three-factor experiment fulfills the needs of most industrial experimentation.

Assume that excessive cap breakage has been occurring on an automatic bottling machine. The capping fixture was redesigned to solve the problem, but requires evaluation. Two identical machines bottling the same products are used in the test, one with and one without modification. Variables in the experiment are the two machines, No. 1 and 2; caps from three suppliers, A, B, and C; and the night-shift and day-shift men, John (J) and Frank (F).

Levels or values of N are 2, 3, and 2, respectively. Table 7 illustrates the experimental design used. Cap suppliers form the columns, machines the rows, and set-up men the entries in this table. Numbers not in parentheses in the body of Table 7 represent the percentage rejects resulting from cap failure. These numbers are multiplied by 20 and an arbitrary zero of 7 taken to simplify the arithmetic. Values in parentheses are the result of this transformation. The arithmetic is further simplified by setting up Tables 8, 9, and 10. Three two-way tables, 8a, 8b, 8c, are constructed by summing over each of the three variables in turn.

Table 7 – Three-Factor Experimental Design

	Set-Up Men	Bottle-Cap Suppliers A	B	C
Experimental Machine No. 1	John J	0.40 (1)	0.35 (0)	0.45 (2)
	Frank F	0.75 (8)	0.85 (10)	0.65 (6)
Control Machine No. 2	John J	0.65 (6)	0.60 (5)	0.70 (7)
	Frank F	0.65 (6)	0.55 (4)	0.75 (8)

Table 8 – Analysis of Columns, Rows, and Entries for Three-Factor Experiment in Table 7

	Columns			
Rows	1+8=9	0+10=10	2+6=8	
	6+6=12	5+4=9	7+8=15	Total
Σ Columns	21	19	23	α=63
(Σ Columns)^2	441	361	529	γ=1331

(a) Columns and Rows

	Columns			Σ Entries	(Σ Entries)^2
Entries	1+6=7	0+5=5	2+7=9	21	441
	8+6=14	10+4=14	6+8=14	42	1764
			Total	α=63	τ=2205

(b) Columns and Entries

	Rows		
Entries	1+0+2=3	6+5+7=18	
	8+10+6=24	6+4+8=18	Total
Σ Rows	27	36	α=63
(Σ Rows)^2	729	1296	β=2025

(c) Rows and Entries

Table 9 – Cumulative Values in Table 7 Squared for Columns, Rows, and Entries

	Columns			
Rows	81	100	64	
	144	81	225	Total
Sum	225	181	289	ϕ=695

(a) Columns and Rows

		Columns			
Entries	J	49	25	81	
	F	196	196	196	Total
Sum		245	221	277	θ=743

(b) Columns and Entries

		Rows		
		No. 1	No. 2	
Entries	J	9	324	
	F	576	324	Total
Sum		585	648	ω=1233

(c) Rows and Entries

Table 10 – Squares of Values in Three-Factor Experiment in Table 7

		A	B	C	
1	J	1	0	4	
	F	64	100	36	
2	J	36	25	49	
	F	36	16	64	Total
	Sum	137	141	153	ε=431

Determination of α and γ for rows and columns, shown in Table 8*a*, is obtained by summing over entries *J* and *F* in Table 7 for each column and row. Sum the rows in Table 8*a*, square the sums, and total these squares to obtain γ. The term α is the total of all individuals in the table. Similarly, the values of τ and β are obtained from Tables 8*b* and 8c, respectively, by summing the entries, squaring the sums, and totaling these squares. Details of the method are evident by studying the tables.

The term ϕ is calculated by inserting the squares of each individual value obtained from Table 8*a* into Table 9*a* and finding the total. Likewise, θ is obtained in Table 9*b* by summing the squares of all individuals from Table 8*b*. The value for ω is calculated from Table 9c by summing the squares of values taken from Table 8c. Table 10 gives ε by squaring all of the individuals taken from Table 7 and summing these squares.

From these tables, the following values are obtained:

$\alpha = 63$, $\beta = 2025$, $\gamma = 1331$, $\tau = 2205$, $\phi = 695$, $\theta = 743$, $\omega = 1233$, $\varepsilon = 431$. These are used to calculate the sum of squares in Table 11. The terms, N_c, N_r, and N_e, are the numbers of columns, rows, and entries, respectively in Table 7 or the

Table 11 — Steps for Calculating Variance, *F*, for Three-Factor Experiment in Table 7

	Sum of Squares, *S*		Degrees of Freedom, *D*	
Columns (*C*)	$S_C = \frac{\gamma}{N_R N_E} - \frac{a^2}{N_C N_R N_E}$	2.00	$D_C = N_C - 1$	2
Rows (*R*)	$S_R = \frac{\beta}{N_C N_E} - \frac{a^2}{N_C N_R N_E}$	6.75	$D_R = N_R - 1$	1
Entries (*E*)	$S_E = \frac{\tau}{N_C N_R} - \frac{a^2}{N_C N_R N_E}$	36.75	$D_E = N_E - 1$	1
Interaction $C \times R$	$S_{CR} = \frac{a^2}{N_C N_R N_E} + \frac{\phi}{N_E} - \frac{\gamma}{N_R N_E} - \frac{\beta}{N_C N_E}$	8.35	$D_{CR} = (N_C - 1)(N_R - 1)$	2
Interaction $C \times E$	$S_{CE} = \frac{a^2}{N_C N_R N_E} + \frac{\theta}{N_R} - \frac{\gamma}{N_R N_E} - \frac{\tau}{N_C N_R}$	2.00	$D_{CE} = (N_C - 1)(N_E - 1)$	2
Interaction $R \times E$	$S_{RE} = \frac{a^2}{N_C N_R N_E} + \frac{\omega}{N_C} - \frac{\tau}{N_C N_R} - \frac{\beta}{N_C N_E}$	36.75	$D_{RE} = (N_R - 1)(N_E - 1)$	1
Residual (*X*)	$S_X = S_T - (S_C + S_R + S_E + S_{CR} + S_{CE} + S_{RE})$	7.65	$D_X = (N_C - 1)(N_R - 1)(N_E - 1)$	2
Total (*T*)	$S_T = \varepsilon - \frac{a^2}{N_C N_R N_E}$	100.25	$D_T = N_C N_R N_E - 1$	11
New Residual (*X'''*)	$S'''_X = S_X + S_{CR} + S_{CE} + S_R + S_C$	26.75	$D'''_X = D_X + D_{CR} + D_{CE} + D_R + D_C$	9

number of levels each of the three factors are raised to. Values of the following radicals are substituted into the equations in Table 11 to obtain the sum of squares.

$$\frac{a^2}{N_C N_R N_E} = \frac{(63)^2}{3(2)(2)} = 330.75$$

$$\frac{\beta}{N_C N_E} = \frac{2025}{3(2)} = 337.5$$

$$\frac{\gamma}{N_R N_E} = \frac{1331}{2(2)} = 332.75$$

$$\frac{\tau}{N_C N_R} = \frac{2205}{3(2)} = 367.5$$

$$\frac{\phi}{N_E} = \frac{695}{2} = 347.5$$

$$\frac{\theta}{N_R} = \frac{743}{2} = 371.5$$

$$\frac{\omega}{N_C} = \frac{1233}{3} = 411.0$$

The value of the residual is the difference between the total sum of squares and the sum of the other six terms in the table.

Degrees of freedom are also calculated for each term in Table 11 using the equations provided. Sum of squares divided by degrees of freedom yields the value of the mean square, *M*, as shown.

The residual is that portion of the variability that is left over after calculating the six primary terms and is a measure of experimental error. The residual mean square is compared in turn with the mean squares of the factors *C*, *R*, and *E* and the interactions $C \times R$, $C \times E$, and $E \times R$, starting with the smallest valued term, to determine if these effects are significant or part of the error. Unless the term under test is at least 3 to 4 times the value of the residual, it can be immediately assumed insignificant. Obviously M_{CE} and M_C in the example, are insignificant when compared with M_X and should be pooled with the residual to obtain a more accurate measure of error:

Term	Sum of Squares	Degrees of Freedom
C	$S_C = 2.00$	2
$C \times E$	$S_{CE} = 2.00$	2
Residual	$S_X = 7.65$	2
New Residual	$S'_X = 11.65$	6

The mean square of the new residual is 11.65/6 = 1.94. The $C \times R$ term is then tested for significance. If found insignificant, it should be pooled with the other interaction to form a new residual. The ratio of the mean square of the term being tested with the mean square of the residual must exceed the variance ratio, *F*, found in Table 12 to be significant at the 95 per cent confidence level.

In the example, the $C \times R$ term has 2 degrees of freedom and the new residual has 6 degrees of freedom, so the ratio of their mean squares must exceed 5.1 to be significant as Table 12 shows. Actually the ratio is 8.35/1.94 = 4.30, indicating

Mean Square, M		Variance Ratio, F	
$M_C = \frac{S_C}{D_C}$	1.00	.....	....
$M_R = \frac{S_R}{D_R}$	6.75	.....	....
$M_E = \frac{S_E}{D_E}$	36.75	$F_E = \frac{M_E}{M'''_X}$	12.37
$M_{CR} = \frac{S_{CR}}{D_{CR}}$	4.18	.....	....
$M_{CE} = \frac{S_{CE}}{D_{CE}}$	1.00	.....	....
$M_{RE} = \frac{S_{RE}}{D_{RE}}$	36.75	$F_{RE} = \frac{M_{RE}}{M'''_X}$	12.37
$M_X = \frac{S_X}{D_X}$	3.83	.....	....
.....	....	.....	....
$M'''_X = \frac{S'''_X}{D'''_X}$	2.97		

an insignificant effect. The $C \times R$ term is pooled with the residual to produce a new residual:

Term	Sum of Squares	Degrees of Freedom
$C \times R$	$S_{CR} = 8.35$	2
Residual	$S''_X = 11.65$	6
New Residual	$S''_X = 20.00$	8

The mean square, M''_X, of the new residual is $20.00/8 = 2.5$. The R term has 1 degree of freedom and the new residual, S''_X, has 8 degrees of freedom, so the ratio of their mean squares must exceed 5.3 to be significant. Actually the ratio is $6.75/2.5 = 2.7$, indicating another insignificant effect. A new residual is formulated:

Term	Sum of Squares	Degrees of Freedom
R	$S_R = 6.75$	1
Residual	$S''_X = 20.00$	8
New Residual	$S'''_X = 26.75$	9

The mean square, M'''_X, of the new residual is $26.75/9 = 2.97$. The E and $R \times E$ terms each have 1 degree of freedom and the new residual S'''_X has 9 degrees of freedom. Therefore, the ratio of their mean squares must exceed 5.15 to be significant. Actually the ratio is $36.75/2.97 = 12.37$, indicating two highly significant effects. It follows that only entries and the interaction between rows and entries are significant at the 95 per cent confidence level.

The greatest influence on cap breakage is the difference in capabilities of the set-up men, John and Frank. John is considerably more capable than Frank in keeping cap breakage to a minimum.

No significant difference exists between caps of various manufacturers or between the two machines used in the test. Frank, however, apparently has greater difficulty in adjusting the experimental machine No. 1 than the control machine No. 2. Hence, the interaction effect observed between Frank and machine No. 1.

The experimental capping fixture offers no significant improvement. An immediate advantage in reducing scrap should result if Frank were to be trained better in his job.

Summary Remarks

The three-factor experimental method, using the straightforward operations described here, has wide application in many engineering problems. The combined effects of fuel, speed, and load on engine performance are one example. Another is the analysis of instrument cooling under various conditions of air flow, power input, and ambient temperature.

Or the vibration-damping coefficient for a new vibration isolator may be determined under varied conditions of load, vibrational amplitude, and frequency. Holding load constant, the effects of frequency and amplitude might be investigated at several replications, i.e., experiment is repeated one or more times. Holding load and amplitude constant, the effect of frequency might be investigated at several replications for both increasing and decreasing frequencies. In this latter case, frequency corresponds to columns, replications to rows, and increasing or decreasing frequency to entries. These various factors can be studied at 2 to 7 levels depending upon the end requirements of the test.

Although the same experiment can be accomplished in less runs using the Latin-square array, the advantages of determining interaction effects between factors are often a vital asset and worth the additional experimental and analytical work required.

Table 12—Variance Ratio, F, for Multiple-Factor Experiments at 95 Per Cent Confidence Level

Degrees of Freedom of Residual	Degrees of Freedom of Term Being Tested					
	1	2	3	4	5	6
1	164	200	216	225	230	234
2	18.5	19.2	19.2	19.3	19.3	19.3
3	10.1	9.6	9.3	9.1	9.0	8.9
4	7.7	6.9	6.6	6.4	6.3	6.2
5	6.6	5.8	5.4	5.2	5.1	5.0
6	6.0	5.1	4.8	4.5	4.4	4.3
7	5.6	4.7	4.4	4.1	4.0	3.9
8	5.3	4.5	4.1	3.8	3.7	3.6
10	5.0	4.1	3.7	3.5	3.3	3.2
12	4.8	3.9	3.5	3.3	3.1	3.0
15	4.5	3.7	3.3	3.1	2.9	2.8
20	4.4	3.5	3.1	2.9	2.7	2.6
40	4.1	3.2	2.9	2.6	2.5	2.3

The Personal Side of Engineering

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Planning for Retirement

EVERYONE who approaches retirement age needs to make some kind of preparation for a satisfying and productive existence, just as he undertakes educational and career preparation at earlier phases.

Some people have little difficulty in making a successful transition into retirement. But a good number of people find this a difficult period. They become bored and frustrated, and feel that their sense of belonging and their self-respect are seriously impaired.

In one study of 483 retired men, only 50 per cent said that they preferred being retired to working on their former jobs. About 40 per cent said it was hard to get adjusted to retirement, and a like number indicated that they were a good deal happier before retirement. Most men in this study had made no plans prior to their retirement.

One misconception which has been refuted in researches on retirement is the tendency for people to think of retirement in terms of travel, play, and relaxation. While this is an appropriate attitude for some people, many productive, successful adult men find the sudden transition to a more relaxed life very difficult. The important satisfactions in their earlier years have been related to their work; they can't be duplicated in leisure-time activities.

Another misconception is that a hobby will be of great value. Findings indicate that rarely can someone develop a satisfying hobby at this late date. Generally, such hobbies need to be started by the age of fifty. If a particular hobby isn't necessary and satisfying in earlier life, why should it suddenly be satisfying at retirement?

Others try to find satisfaction in their families and by going back to live with their children. But, since this is not an independent, authoritative, and generally useful relationship, many a retirant has found this to be a disappointing, frustrating experience.

Based upon knowledge accumulated to date, several positive steps can be taken by those who are getting on toward the retirement age. To begin with, men in their middle to late fifties should begin thinking seriously of what they will do once they retire. A retirement program, just like an educational or career plan, must be tailored to the specific needs of the individual. What appears to be a satisfactory experience for a friend or colleague may not fill the bill for oneself.

Those facing retirement might also do well to seek assistance and counsel in determining their plans. Programs have been started by many companies to provide such counseling assistance. In addition, literature and community programs (such as "senior council" activities) offer assistance to the prospective retirant.

Perhaps the most important thing to keep in mind is that retirement merely marks the transition from one stage of life to another. It is not the end of life. Those who approach the problem from the standpoint of retiring *to* something rather than retiring *from* something—who view it as a change in activity rather than a cessation of activity—will find the going easier. By intelligent planning, undertaken well in advance of retirement, one's needs for self-expression, recognition, security, and accomplishment can continue to be satisfied.

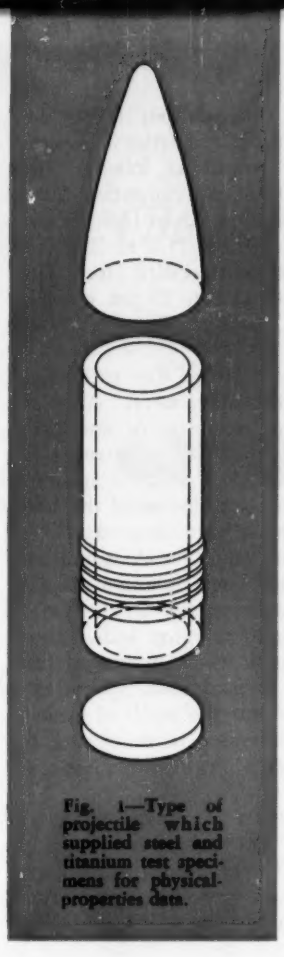

Fig. 1—Type of projectile which supplied steel and titanium test specimens for physical-properties data.

Tensile properties of a material are not the sole index of structural reliability of dynamically stressed parts. Other requirements can be specified to help control metal fabrication and predict serviceability of parts. This idea is substantiated here in . . .

The Case for **Charpy Impact Tests**

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MILLIONS of dollars are spent each year for scrapping or reworking metal parts in process because they do not satisfy specified property requirements. More seriously, high costs result when metal parts are accepted for use and subsequently fail in service.

A portion of this trouble can be attributed to the method of specifying the physical properties required. Although failure from poorly specified physical properties is relatively infrequent, such situations cannot be tolerated.

In practice, materials for structural purposes are specified by physical properties required to satisfy service loads. These properties are assured by laboratory tests of a standard tensile-test specimen. The test provides ultimate tensile strength, yield strength, reduction in area, and elongation of the material. However, the value of certain of these physical properties for predicting successful service of a part is questionable.[1]

Seldom does the literature provide actual test data correlating physical properties with service results. This article presents data to support the conclusion that tensile tests do not tell the whole story. Extensive development testing of structural parts over the past four years has shown that the structural integrity of metal parts can be further assured by the use of the Charpy V-Notch requirement. In recent exhaustive tests conducted by Watertown Arsenal on large quantities of closely controlled specimens, the Charpy requirement was proved a reliable and reproducible test.[2]

Data presented in this article were obtained from the steel and titanium structural parts of a large-caliber artillery projectile—one of the most severely stressed components in use by the military, Fig. 1. Its loading and stress conditions can be correlated to many specific applications for which these data can be useful.

In terms of applied load, an artillery projectile, fired from a gun, has undergone loading from zero to maximum in approximately 3 to 10 milliseconds and a continuing reduced load to approximately 20 milliseconds. This is considered a "sudden" load rather than an impact load.

Dynamic load during firing is determined by maximum gun-chamber pressure (36,000 to 40,000 psi) and the base area of the projectile (50 sq in. for an 8-in. shell). This type of load is similar to that experienced by parts such as those on heavy-duty metal forming equipment, landing gears on large aircraft, and heavy vehicles on rough roads.

Good Ductility—Poor Impact: Interest in establishing significant physical-properties tests for structural metal parts was generated as the result of

[1]References are tabulated at end of article.

body failures of a new 8-in. artillery projectile. Design calculations showed that a yield strength of 70,000 psi was adequate to satisfy the worst loading conditions encountered by this projectile. In accordance with past standards for insuring satisfactory service strength, steel bodies were procured having the following physical properties: 70,000-psi minimum yield strength at 0.1 per cent offset, 15 per cent elongation, and 45 per cent reduction in area.

Firing tests of this shell resulted in body failure while the projectile traveled through the bore of the weapon. A detailed examination was undertaken on specimens machined from the bodies recovered after the test firing. Results are shown in Table 1.

Considering the safety factor in all design calculations, these data represent acceptable steel for this use. Metallurgical study was made for more detailed information. Charpy V-Notch test specimens were machined from the recovered bodies and tested at −40 F in the Sonntag Universal Impact Machine.* Charpy test values were 3.0, 2.0, and 2.5 ft-lb, respectively, for the three body specimens.[3]

These data provided the first indication of the true condition of the steel. The Charpy value at −40 F for properly heat-treated steel of 70,000-psi yield strength is 35 ft-lb.[4] For comparative purposes, it is mentioned that the Charpy value at the same temperature for cast iron is approximately 2 to 3 ft-lb. Although the projectile bodies met yield-strength and ductility requirements (Table 1), they had a toughness only similar to that of cast iron. Analysis of micro-etch and macro-etch specimens showed the steel to be extremely coarse-grained in structure.[3]

Table 1—Tensile Properties of Projectile Bodies

Body	Ultimate Tensile Stress (psi)	Yield Stress (psi)	Elongation (per cent)	Reduction In Area (per cent)
1	102,000	69,500	19.5	26.5
2	106,000	84,000	16.4	30.3
3	122,000	95,000	13.5	31.7

A coarse-grained structure need not adversely affect tensile strength of the material. It can, however, decrease toughness drastically. Investigation revealed that this material had been tested and found to meet requirements. However, the supplier had inadvertently shipped the material in the as-formed condition without subsequent heat treatment.

Values for yield strength, elongation, and reduction in area failed to reveal the existence of such a condition, and therefore were not sufficient to insure proper functioning of the part in service.

Poor Ductility—Good Impact: To further substantiate the usefulness of the Charpy V-Notch requirement, data from a similar development program are presented. A newly developed high-strength titanium alloy was to be used for an 8-in. projectile body.

The initial bodies, as received from the supplier, exhibited substandard tensile properties. Properties for four bodies tested ranged as follows: Yield strength, 123,000 to 133,000 psi; elongation, 2.9 to 6.4 per cent; reduction in area, 6.6 to 14.0 per cent; and Charpy V-Notch (−40 F), 11.5 to 12.5 ft-lb. Original design requirements called for: Yield strength, 135,000 psi; elongation, 15 per cent; reduction in area, 30 per cent; and Charpy V-Notch (−40 F), 10 ft-lb.

The firing test, however, proved that each of the four projectiles was structurally sound. After the test, the recovered bodies were studied and found to be dimensionally true with no permanent deformations. The extremely poor ductility apparently did not compromise the functioning of the body. However, the Charpy values were adequate.

It was realized that low values for elongation and reduction in area indicated some abnormal situation in the heat treatment of the metal. In this particular case, the high-strength titanium bodies represented the first lot of parts which progressed from laboratory investigation to production-type fabrication. The poor ductility was the result of exploratory metallurgical methods used in developing the alloy. Later improvements in heat-treatment resolved this condition.

Obviously, the low values of elongation and reduction in area would not have been useful in predicting the serviceability of the bodies, but they did reveal that something was wrong. It is strongly believed that these properties should be maintained in specifying metal parts to isolate trouble areas in the fabrication of the material and to insure high quality in the final part. However, these values alone should not be used as the basis of acceptance or rejection of parts. A better criterion is one where both yield strength and Charpy value are used.

How To Use Charpy Tests: The Charpy V-Notch requirement can help predict serviceability of a part even when normal heat treatment and fabrication are used. Many steel alloys exhibit a transition region wherein the metal structure changes from ductile to extremely brittle. This region is completely undetectable by the standard tensile test when the test is conducted above the transition temperature. Alloys are known for which this transition region occurs at as high as room temperature.

If the tensile test data alone are used as the basis for acceptance, and a high transition temperature exists, parts could be put into service which would fail the first time they experience temperatures lower than that of the tensile test, i.e., room temperature. Existence of a high transition region and the subsequent brittle failure are easily detected by the Charpy V-Notch test conducted at the lowest service temperature expected for the part.

*For military purposes, a minimum Charpy V-notch value is specified at −40 F since this temperature represents the lowest temperature at which most equipment is expected to operate.

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2. David E. Driscoll—*Reproducibility of Charpy Impact Test*, American Society for Testing Materials, Philadelphia.
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Checklist of coding techniques for CONTROL IDENTIFICATION

- **Color**
- **Sound**
- **Shape**
- **Texture**
- **Location**
- **Size**
- **Operation**
- **Combinations**

JOSEPH L. SEMINARA
Human Factors Specialist
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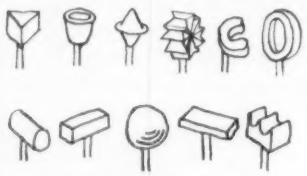
PROPER identification of controls is essential to effective operator performance with equipment. Misidentification of controls is often listed as one of the most important reasons for accidents and equipment failures. For example, a survey of Army Air Force accidents during World War II revealed that over 400 of the accidents which occurred in a 22 month period were caused by incorrect control identifications.

In most situations, properly designed labels are sufficient for efficient operator performance. However, when the equipment being designed will be operated under stressful conditions, special or additional precautions should be taken to render a series of control elements easily distinguishable.

Such stressful conditions include those instances where the normal visual cues are reduced or eliminated, when the operator is overburdened because of the complexity of his task, and where a misidentification could jeopardize the survival of the man or the machine. Various techniques which the designer can use to ensure more reliable and effective operator performance are summarized in the table appearing on the following pages, 138 and 139.

Coding Techniques for Controls

Code Elements	Advantages	Limitations
Color Coding Both normal vision and "color blind" operators can distinguish the following code colors: Red 1110 — Black 1770 White 1755 — Purple 2715 Yellow 1310 — Buff 1745 Orange 1210 — Gray 1625 Blue 10 B 7/6 (Numbers refer to Federal Specification TT-C-595, *Colors For Ready Mixed Paints*. Blue 10 B 7/6 is an A. H. Munsell notation; See *Book of Color*, Munsell Color Book Co. Inc., Baltimore, Md., 1942.	Easy to implement. Can standardize association between a given color and a certain function; e.g., use red for "ARM" switch. Requires no extra panel space.	Color coded controls must be viewed directly; therefore, this technique requires good illumination for maximum effectiveness.
Sound Coding Easily identifiable auditory cues can be incorporated into the control mechanism. For example, a ratchet type sound or detent clicks can be utilized to heighten identification of key controls. Other types of sounds can also be used. Where this technique is employed, the absence of sound in manipulating a control would also naturally serve as a cue.	Permits ready identification of key controls since the sound cue will immediately command the operator's attention.	Limited number of distinguishable sounds that can be easily incorporated into controls. May prove disturbing to other operators in the vicinity. Requires the operator to actually change the control position before awareness of the auditory cue is possible. Should only be used on critical controls where the operator's attention must be directed toward the control manipulated.
Shape Coding Distinctive shapes for controls have been determined by research. Easily distinguishable shapes applicable for lever type controls are:  Similar easily identifiable shapes are available for knob type controls. (See WADC Technical Report 56-172, *Design of Controls*, Astia Document Service, Knott Building, Dayton, Ohio.)	Permits operation where visual cues are absent or reduced from normal. Can standardize associations between given shapes and functions. Can use shapes which indicate the function of the control; e.g., flap shape for landing flap control.	If the equipment must be operated with gloves on, the effectiveness of shape cues is reduced.
Texture Coding The surface texture of controls can be varied to permit identification by "feel". No specific number of texture code elements has been determined. However, the possibilities are practically limitless; e.g., abrasive paper type surface, raised hemispheres, grooves or ridges, etc. These surfaces should be as dissimilar as possible. When more than three such surfaces are employed on a unit, the texture code must be carefully pretested for ease of distinguishability.	Same as for Shape Coding. Also, particularly useful for coding components which are located behind an access door and hidden from view. Texture cues help the maintenance operator to distinguish between parts which must be replaced.	Same as for Shape Coding.

Code Elements	Advantages	Limitations
Location Coding Designate specific location on a control panel for a given control. If sufficient separation is allowed between controls, "blind reaching" habits will be developed, thereby reducing need for visual attention. When controls are optimally placed at shoulder level, a separation of from 6 to 8 in. is sufficient for location coding. For less desirable areas of a panel, the separation should be doubled to provide dependable cues.	Reduces visual burden. Permits standardization from panel to panel; e.g., always place "Power ON-OFF" switch in lower left-hand corner of panel.	Increased panel space may be required. Should be combined with additional coding technique in the case of critical controls.
Size Coding The size of controls can serve as a cue in differentiating between adjacent controls. No specific number of size gradations can be given. However, the operator's ability to judge size differences is limited and the diameters of size coded knobs should vary by a factor of one third to be on the safe side.	Helpful when visual cues are absent or reduced from normal. Simple to implement.	Only a limited number of specific code elements are available since design is limited by the maximum size that is practical and the size intervals must be relatively large.
Operational Differences Controls may also be distinguished by varying such operational characteristics as: 1. Force required to activate. 2. Direction of control movement; i.e., counterclockwise or clockwise, etc. 3. Hand vs. pedal elements.	• • •	Care should be taken to avoid violation of control design principles, e.g., in using activation force variation as a cue, the forces should all fall within the operator's normal range of abilities.
Combination Methods More than one coding technique can be employed at one time. Some techniques are more readily combinable than others without extra design effort. For example, color coding can be applied along with most of the other coding methods.	• • •	The question of how many coding techniques are really necessary cannot be answered simply. The precautions taken by the designer will depend on how "foolproof" it is necessary to make the equipment. In such decisions the following considerations must be taken into account: 1. Intelligence level of the user. 2. Training given to the operator. 3. Complexity of the operator's task. 4. Stresses that the operator might be subjected to during operation of the equipment. 5. Design limitations such as available space, illumination, cost, etc. When in doubt, it is, of course, always best to err on the side of overprecaution.

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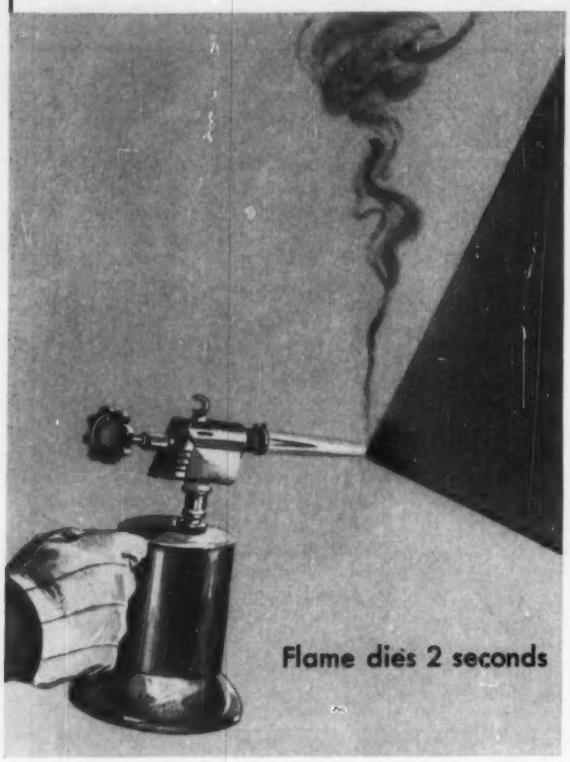

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Recent developments in

Refractory Sheet-Metal Structures

ALAN V. LEVY and SAUL E. BRAMER
Marquardt Aircraft Co.
Van Nuys, Calif.

MOLYBDENUM is a unique material from a design standpoint in that there is little need to be concerned about its ability to perform at high temperatures. There is, however, great need for concern and extreme care in handling molybdenum components at no-load ambient-temperature conditions. In its usable alloyed forms, molybdenum tends to behave in a brittle manner at room temperature and exhibits a high brittle-to-ductile transition temperature. In fact, most of today's usable refractory metals behave similarly in either bending or impact. It is this single fact that limits applications of these alloys for the present to special areas.

Rapid development of columbium-base alloys, such as the new General Electric F44 and F48 alloys, has resulted in specific compositions that are completely ductile at temperatures below room temperature. Strength levels for several of these alloys are considerably below those of the best molybdenum alloys and actually are only comparable to the strongest nickel-base alloy above 2000 F. However, the promise of high-strength, completely ductile materials in the future is great.

Of the four principal refractory metals that are available in sufficient quantity for structural applications, only molybdenum and columbium are being considered for sheet-metal components today. Tantalum, which is the most ductile of the four and has the best overall fabricability, is not used because its strength-to-weight ratio is very low and its cost comparatively high. Tungsten is only now being investigated experimentally in sheet form and holds promise for use at temperatures between 3000 and 3500 F. Below this temperature range, strength-to-weight ratio is very low compared to molybdenum.

Properties of Molybdenum: The high modulus of elasticity of molybdenum is an attractive property, especially in applications where a thin sheet-metal structure is desired. An additional attractive property of molybdenum alloys is excellent creep strength. For low-load applications in high-temperature environments, molybdenum is well suited for short time periods. For longer life applications, present molybdenum alloys are suitable for service at temperatures in the 2000 to 2500 F range. The combination of relatively high thermal conductivity, low thermal-expansion coefficient, low specific heat, and reasonably high surface emissivity makes molybdenum desirable for exterior surfaces of high-temperature components.

Uniformity and level of the following properties of molybdenum-alloy sheet material are considered acceptable and attest to the quality of alloys available today:

1. Ambient tensile strength and elongation.
2. Chemical composition.
3. Surface condition and flatness (after surface grinding, 0.002 to 0.005 in.).
4. Formability and weldability.

The acceptable status of these properties has only been reached in the past year. Prior to that time, almost any level of a given property could be expected from heat to heat.

The unacceptable-level properties of molybdenum are:

1. Brittle-ductile transition temperature. The majority of production sheet metal has a bend transition temperature at or above room temperature. The impact transition temperature of molybdenum alloys has consistently been in the 300 to 500 F range. One of the interesting aspects of the bend transition property is the significant improvement made by removal of contaminated material by surface grinding.
2. Laminations. A critical problem for users of molybdenum-alloy sheet results from laminations in the material. Since most metals are best reduced by hot rolling at 70 to 80 per cent of their melting temperatures, equipment for rolling at temperatures to 2300 F is adequate except for the refractory metals. Therefore, because molybdenum is rolled at less than 50 per cent of its melting temperature, large differential shear stresses exist between the layers of sheet passing through the rolls. Shear

separation and areas of high residual shear stress are induced primarily along the flat grain boundaries that exist in the plane of the sheet.

3. Preferred-angle cracking of 45 deg. Molybdenum sheet exhibits an anisotropic property in its tendency to propagate cracks at very fast rates in a direction 45 deg from its rolling direction. This behavior is particularly harmful because of the apparent extreme ease with which the cracks can traverse great distances. It has been observed that this type of cracking requires a high stress concentration, such as exists at a notch or a short transverse crack in a fusion weld, to be initiated.
4. Recrystallization. Present properties of refractory metals are enhanced only by introducing cold work into the sheet during its last rolling reduction and after final annealing. Ultimate tensile strength of one alloy is increased from 33,500 to 74,000 psi at 2000 F by cold working. If the recrystallization temperature is exceeded either in service or in processing such as in a coating operation, this marked strength increase is lost.
5. Controlling interstitial alloying elements. Problems involved in controlling the interstitial alloying elements, oxygen and nitrogen, in molybdenum alloys is complicated by two facts. It is difficult to determine accurately the level of these elements present, and, at the lower quantities, it is difficult to set an acceptable minimum that is based on a knowledge of the detrimental effects that occur.

Sectioning: Sheets of molybdenum alloy can be sectioned by shearing and sawing when proper precautions are taken. Machine shearing is done by heating the entire sheet to several hundred degrees and then locally torch heating the area to be sheared to between 400 and 1000 F. In hand shearing, the material should be locally heated to a dull red (about 1000 F) immediately ahead of the shear blade before cutting. By heating to these temperatures, the sheet will be well above its brittle-to-ductile transition range. Cracking and opening up of laminations will be eliminated. By using a fine-tooth blade at very high speeds on a bandsaw, flat patterns and formed molybdenum sheet sections can be cut. The creation of a heat zone immediately ahead of the saw blade as a result of friction caused by the high speed eliminates cracking.

Forming: The basic technique required to form shapes from molybdenum sheet is primarily dependent upon the ability to control forming temperature as related to forming speeds and sheet thickness. Because of the high cost of the material, chipless operations such as extruding, die forging, radial draw forming, manual spinning, hydroforming, impact forming, and spin forging should be utilized as much as possible. In general, it has been found that as long as molybdenum sheet is formed at elevated temperatures, it is as formable as any other alloy and takes complex shapes accurately.

Mechanical Fastening: Rivets used to join molybdenum-sheet parts must be heated at 1000 to 1200 F. The metal component being joined must be kept at several hundred degrees to insure that the base metal will not crack when the rivet is squeezed. Bolts can be installed at room temperature, but bolt holes must be aligned perfectly. Any excess torque due to interference will shear the bolt before the threads deform. Bolts and screws can be coated for oxidation resistance prior to assembly. However, an allowance must be made for coating thickness. Riveted joints have been successfully coated after assembly.

Resistance Welding: The best electrodes to use are those which have a very high conductivity and are not the current-collector type. Current-collector types have face-heating tendencies and make the electrodes stick to the base metal, causing copper diffusion into the base metal. To produce optimum spot welds, molybdenum's characteristics of having a high thermal conductivity and high brittle-to-ductile transition temperature must be accounted for. The high thermal conductivity dissipates the heat rapidly away from the joining area and long weld-current times result in nonbonding of the faying surfaces.

Short cycling (welding amperage brought in rapidly and discontinued almost immediately) must be used to produce spot welds. To avoid surface cracking, preheat control must be used to raise the temperature of the material above the transition temperature prior to applying welding current. Immediately after welding, post-heating and forging actions are initiated. The post heat keeps the material above the brittle-to-ductile transition temperature and forging aids grain refinement.

Fusion Welding: Molybdenum has been successfully fusion welded in the open air using local protection without the need for inert atmosphere boxes. Inert atmospheres (either helium or argon or their combination) are supplied by modifying the torch and backup bars to receive an inert-gas supply.

Molybdenum weldments are very sensitive to any restraints imposed on the joint. The correct combination of hold-down bar pressure and part preheat temperature can eliminate cross cracking in weldments. A 300 F preheat can decrease welding current by 80 amp under that used to weld specimens with no preheat. When all welding conditions are constant, a variation of only 25 F in preheat temperature results in holes being blown the full length of the weld bead because of the sensitivity of molten molybdenum to temperature. Therefore, it is desirable that preheat temperature variations of ± 5 F be maintained to produce reliable weldments.

Another variable that affects weld-bend transition temperature is welding speed. An increase in welding speed can decrease the bend transition temperature by 200 F. The grain-size gradient is decreased with increasing weld speed, and grains in the center of the bead become more favorably oriented to reduce the bend transition temperature.

It has also been determined that a post-weld stress-relieving treatment can reduce the bend transition temperature. Stress relieving at 1700 F for 4 hr reduces transition temperature by 25 to 50 F. However, a 1500-F stress-relieving treatment for 4 hr has no effect on transition temperature.

Machining: For most machining operations, molybdenum cuts like the stainless steels. A carbide-tipped tool should be used. When sheet edges are machined to prepare them for welding, mild-steel bars should

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be clamped on each side of the sheet to prevent chipping and separation of the planes of weakness.

In thread-chasing operations, the material machines like cast iron. Powdery, discontinuous chips are produced. For drilling and boring operations, a chlorinated cutting oil should be used so that chips can be continuously flushed from the hole because their abrasiveness can significantly decrease tool life.

Coatings for Oxidation Resistance: The refractory metals, other than molybdenum, form an oxide scale when exposed to an oxidizing atmosphere at elevated temperatures. However, above 1000 F molybdenum volatilizes as molybdic oxide, and the rate of this phenomenon increases rapidly as temperature increases. At about 1400 F, rate of volatilization equals rate of formation. At 1800 F, the oxidation rate for molybdenum in slowly flowing air is greater than 0.022 in. per hr.

Coatings developed to overcome this serious disadvantage include hot dip, paint and sinter, flame sprayed, electroplated, electroless plated, electrophoretic deposited, vapor phase deposition, flame plated, cementation, and clad. Two of these will be discussed.

1. Chromalloy W-2 (cementation) coating is the best tested to date. It is applied by packing the part in a powdered mixture in a retort, sealing the retort, and heating at 2000 F for a number of hours. The powder generates a gas which diffuses into the molybdenum and results in a thin (approximately 0.002 in.) alloy case with a surface finish as smooth as the original base-metal. Advantages of this coating include unlimited throwing power, uniformity, thin case-depth on all exposed surfaces, excellent reproducibility, diffusion temperature below the recrystallization temperature of the base metal, resistance to thermal shock, and metallic-like surface finish.

2. Climax Molybdenum Al-Cr-Si coating (flame sprayed) is applied by flame spraying an Al-Cr-Si powdered mixture which is diffused into the base metal at about 2000 F in an argon or hydrogen atmosphere. However, this coating has poor impact resistance and cannot

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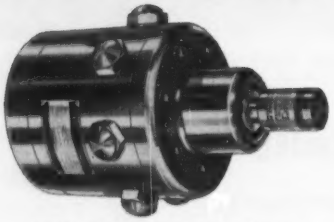

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readily cover complex shapes. Also, it builds up to a thickness of several thousandths of an inch, and surface finish is poor.

Many other coatings have been tested, but none performed well enough to be considered for applications. At lower temperatures (1800 to 2200 F) metal claddings and platings have shown considerable promise. However, for large sheet-metal components operating at temperatures in excess of 2400 F, the cementation type coatings show the most promise.

SAE paper 56T, SAE National Aeronautic Meeting, New York, March, 1959; 22 pp.

electrical

Printed-Circuit Motors

J. Henry-Baudot and R. P. Burr, Printed Motors Inc.

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AIEE paper CP59-76, AIEE Winter General Meeting, New York, February, 1959; 7 pp.

Specifying Pulse Transformers For Computer Use

R. R. Blessing, International Business Machines Corp.

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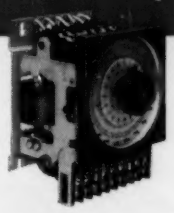

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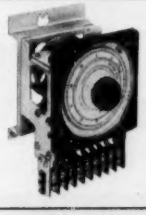

model HZ200
ADD-SUBTRACT COUNTER
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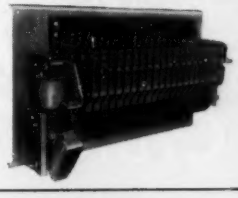

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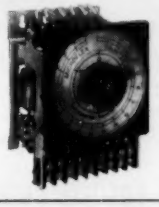

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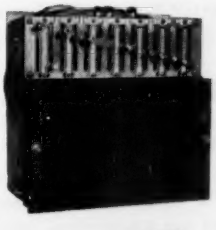

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marily concerned with the electromagnetic characteristics of the pulse transformer. In conjunction with the characterization, mechanical and electrical properties of the unit are also of concern.

AIEE paper CP59-119, *AIEE Winter General Meeting, New York, February,* 1959; 5 *pp.*

Electronic Transformer Design By Digital Computers

L. F. Deise, W. Etchison, and R. Lee, Westinghouse Electric Corp.

A description of procedures, results, and benefits pertaining to the application of digital computers to the design of electronic transformers. Over-all gains are improvement in reliability because of better transformer standardization, reduction in design engineering time, and more effective use of engineering talent. Computer designs tend to be more uniform than those done by hand and are less dependent on individual whims. Designs are easier to check and control. Because of the flexibility and adaptability of existing programs, it is predicted that further applications to audio, carrier, and pulse transformers will soon appear.

AIEE paper CP59-120, *AIEE Winter General Meeting, New York, February,* 1959; 9 *pp.*

lubrication

Recent Developments in Lubricating Heavy-Duty Gearing

G. P. Maurer, The Falk Corp.

A report on the endurance of lubricant film on gear teeth. Tests determine frequency of application and quantity of lubricant required when intermittent lubricating methods are employed. Differences in characteristics of various lubricants are recorded. Requirements for number and location of spray nozzles to obtain effective and adequate lubricant coverage are included.

ASLE paper 59GS-5, *ASLE First Gear Symposium, Chicago, January,* 1959; 15 *pp.*

Effects of Lubricants on Gear-Tooth Scuffing

P. M. Ku and B. B. Barber, Southwest Research Institute

Effects of some lubricant variables and other relevant factors on gear-tooth scuffing. Scuffing is defined

as any form of scoring or abrasion of tooth surface due to metal-to-metal contact. The scuff-limited load is defined as the tooth load at which an arbitrary amount of the working-tooth area is scuffed. Factors considered include lubricant bulk viscosity, lubricant type and deterioration, test gear and machine variables, gear speed, location and rate of lubricant supply, lubricant supply temperature, and presence of inert gas atmospheres. Results are compared with those of other published data.

ASLE paper 59GS-4, *ASLE First Gear Symposium, Chicago, January,* 1959; 18 *pp.*

Dry Powdered Lubricants for Applications at 1000 F

C. M. Allen, L. B. Sibley, and S. L. Cosgrove, Battelle Memorial Institute

Friction and wear behavior of selected solid lubricants. Data are obtained at 1000 F for sliding speeds of 120 and 700 fpm under initial Hertzian contact stresses of about 250,000 psi. Conventional solid lubricant materials such as lead oxide, molybdenum disulphide, and graphite are evaluated. A new dry solid lubricant, metal-free phthalocyanine is found to have superior lubricating qualities. Wear specimens of AISI Type M-1 tool steel and titanium carbide-nickel-molybdenum cermet show the most promise for high-temperature sliding systems.

ASLE paper 59AM 1A-1, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 28 *pp.*

Modern Techniques for Spray Lubricating Industrial Gearing

E. J. Gesdorf, The Farval Corp.

A brief history of the development of spray lubrication for industrial-gear applications. Major features of a spray system are covered.

ASLE paper 59AM 2C-5, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 9 *pp.*

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AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.; papers 35 cents to members, 50 cents to nonmembers.

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Circle 483 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Pipe

Dimensions and weights per foot of pipe in sizes from ⅛ to 36 in. for all schedules are found in Bulletin TDC-191. Wall thickness and inside diameter are given for each schedule. 4 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 601 on Page 19

Self-Sealing Fasteners

Line of single unit, high pressure seals and fasteners for variety of uses is described in illustrated Catalog 359. Hexseals, Seelskrews, Seelbolts, and Seelrivits are offered in range of sizes. 4 pages. A.P.M. Sales Corp., 252 Hawthorne Ave., Yonkers, N. Y. D

Circle 602 on Page 19

Functional Fluids

Fluids which dissipate or convey heat, transmit pressure, neutralize pressure by lubrication, withstand extreme cold, resist evaporation, and remain stable under high heat are detailed in folder. Properties of 20 such fluids are covered. 6 pages. Monsanto Chemical Co., Organic Chemicals Div., Lindbergh & Olive Street Rd., St. Louis 24, Mo. I

Circle 603 on Page 19

Belts

Alphabetical and numerical listings of Browning V-S belts and those of other manufacturers are found in Bulletin V-173-B. An interchange guide and a conversion table for certain belts are also included. 12 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 604 on Page 19

Castings

Medium gray iron castings varying in weight from 1 to 1900 lb are shown in illustrated folder. Facilities of two integrated foundry units for their production are described. 4 pages. Chromalloy Corp., Elyria Foundry Div., Elyria, Ohio. G

Circle 605 on Page 19

Indicator Lights

Roto-Tellite word indicator lights used to indicate faults or functions of missile ground support or airborne equipment are subject of illustrated Catalog 59a. They feature rotating lamp capsule for rebulbing, replaceable legends, and flush mounting. 16 pages. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif. L

Circle 606 on Page 19

Magnesium Alloys

"Shop Guide for Elevated-Temperature Magnesium Alloys" describes recommended practices for working magnesium alloys of the thorium and rare earth metal families. Machining, forming, joining, assembly protection, and finishing are covered. Tables list technical data. 28 pages. Dow Chemical Co., Midland, Mich. H

Circle 607 on Page 19

Steam Specialties

Valves, thermostatic traps, float and thermostatic traps, steam traps, and pipe line strainers are illustrated and described in Bulletin 203. Dimensions, capacities, patterns, weights, and accessories are highlighted. Construction and operation are explained. 12 pages. American Air Filter Co., Illinois Engineering Div., 215 Central Ave., Louisville 8, Ky. G

Circle 608 on Page 19

Stainless Fastenings

Over 7000 items and sizes in stainless steel fastenings are covered in illustrated Catalog 59-A Cap screws and bolts, nuts, washers, machine screws, wood screws, setscrews, sheet metal screws, rivets, cotter pins, piano hinges, pails, funnels, scoops, and screw machine products are covered. 24 pages. Star Stainless Screw Co., 699 Union Blvd., Paterson 2, N. J. D

Circle 609 on Page 19

Plastic Sheet Forming

Low pressure forming of thermoplastic sheet is subject of Boltaron manual. It covers materials, storage, cutting and layout, heating, molds or formers, forming methods, machining and trimming, assembly, cleaning, decorating, design, cross-sectional control, cost and economics, and case histories. 48 pages. General Tire & Rubber Co., Bolta Products Div., 70 Garden St., Lawrence, Mass. B

Circle 610 on Page 19

Gearmotors & Fluid Drives

Booklet 2747 on gearmotors, Motogears, and fluid drives provides selection and application information, dimensional data, load ratings, and appropriate coupling information. Gearmotors and Motogears are offered in ratings up to 100 hp with output speeds from 280 down to 1.8 rpm. 48 pages. Link-Belt Co., Prudential Plaza, Chicago 1, Ill. J

Circle 611 on Page 19

Couplings

"Connections That Count" folder contains two bulletins which describe Roto-Lock aircraft series and all-purpose industrial couplings for hoses, pipes, and tubing. Couplings can be used in raw crude, process liquid, and jet aircraft and missile fuel service. 4 pages each. Roto-Lock Couplings Inc., 4937 Firestone Blvd., South Gate, Calif. L

Circle 612 on Page 19

Strain Gages

Improved design and engineering features of SR-4 etched foil strain gages for stress analysis are detailed in illustrated Bulletin 4320. Specifications are included, along with gage features and available types. 6 pages. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass. B

Circle 613 on Page 19

Cd, Pb & Sn Products

Cadmium, lead, and tin products available for industrial use are listed in bulletin. Cadmium is available in sheets, plates, strip, circles, wires, and rods in various sizes and analyses. Lead and tin are offered in similar forms. 4 pages. White Metal Rolling & Stamping Corp., 92 Moultrie St., Brooklyn 22, N. Y. D

Circle 614 on Page 19

Alloy Studs & Hex Nuts

Advantages of steel alloy studs, threaded bars, and high carbon hex nuts are outlined in Folder 1019-R. Physical properties are listed. Data cover standard, special, and stainless steel grades. 4 pages. Republic Steel Corp., 1441 Republic Bldg., Cleveland 1, Ohio. F

Circle 615 on Page 19

Pipe Fittings & Flanges

Long tangent fittings, unusual rotating insert flanges, and a reversible plug-and-cap are features of Pipe-Mate light-wall stainless steel fittings and flanges described in Bulletin TT944A. Joining of fittings and pipe are shown. 6 pages. Chemetron Corp., Tube Turns Div., Louisville 1, Ky. G

Circle 616 on Page 19

Check Valves

Circular 588 illustrates and lists bronze, iron, and steel check valves with specifications. Valves are used for boiler feed lines and for controlling chemicals and gases. 2 pages. Lunkenheimer Co., Cincinnati 14, Ohio. G

Circle 617 on Page 19

Heating Elements

Advantages of film-type, sprayed-on heating element are pointed up in Catalog HB-3-359 which also details physical, electrical, and thermal characteristics. Sprayed-on heating element is especially designed for hard-to-heat contour surfaces. 12 pages. Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, Calif. L

Circle 618 on Page 19

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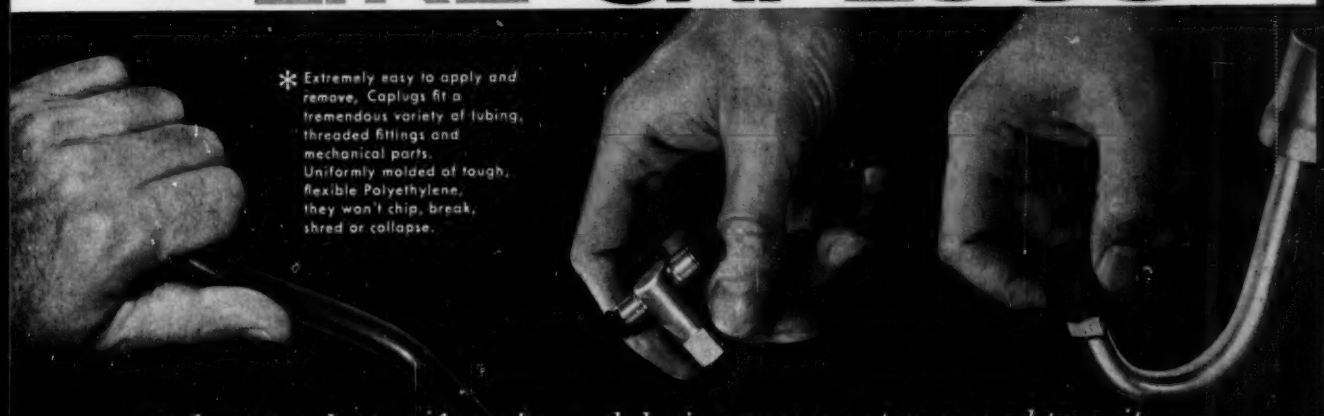

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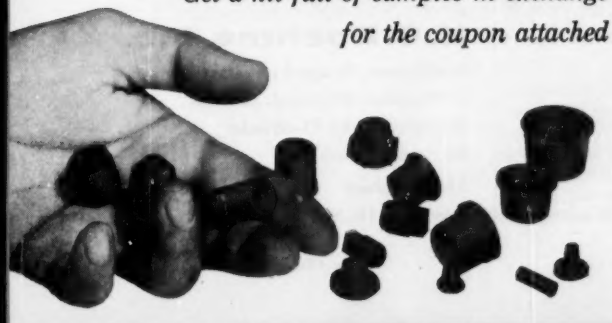

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Circle 484 on Page 19

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Vibration can't loosen Loctite-treated fasteners

The HOMELITE six-horsepower chain saw weighs only 19 pounds. So much power per pound requires maximum resistance to vibration in the fasteners holding parts together.

LOCTITE, the liquid lock washer, locks all critical fasteners on this gasoline-driven chain saw . . . providing dependable service in rugged field use.

LOCTITE Sealant is a liquid which hardens between metal parts to form a bond with greater holding power than any mechanical locking device. The added holding power of LOCTITE-treated fasteners allows Homelite to use reduced tightening torques and thus avoid stripping threads in the aluminum castings.

While adding to product reliability, LOCTITE provides substantial cost savings. At Homelite, the 27 different size fasteners required in assembling the chain saws are treated with LOCTITE by tumbling in plastic bags. Treated screws store for days . . . lock only when assembled.

There's a Loctite application method suited to all production requirements. If your product faces shock and vibration in use, you can eliminate breakdowns due to loose threaded fasteners . . . cut service cost and customer complaints . . . by using Loctite. Write for literature and free sample.

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In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 485 on Page 19

Fractional HP Motors

Basic line of Redmond fractional horsepower electric motors, blowers, and special products covered in Catalog 6773 includes shaded pole, permanent split capacitor, and direct-current motors. Basic engineering information is given. 12 pages. Redmond Co., Owosso, Mich. H

Circle 619 on Page 19

Tubing & Facilities

Revised Ostuco tubing and facilities Catalog CF-3 describes carbon and alloy seamless steel tubing in mechanical, pressure, aircraft mechanical, and airframe grades. It illustrates seamless steel tube production and also covers electric welded carbon steel tubing in mechanical and pressure grades. 14 pages. Copperweld Steel Co., Ohio Seamless Tube Div., Shelby, Ohio. G

Circle 620 on Page 19

Vulcanized Fiber

Six standard and five special grades of vulcanized fiber are described in Data Sheet 2-0. Featured is a chart which lists suggested uses, grades, specs, color and size, and engineering data. Thicknesses for the 56 x 90-in. sheets range from 0.004 to 1 in. 4 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 621 on Page 19

Fasteners Corrosion Guide

Every commonly-used metal which this company uses is tabulated to show approximate physical and mechanical properties in its comprehensive "Corrosion Guide" for fasteners. Booklet suggests proper metal for longest service life of a product. Metals are cross-referenced to ASTM, Military, and Federal specifications. 24 pages. H. M. Harper Co., Morton Grove, Ill. J

Circle 622 on Page 19

Plastic Cable

Application, construction and electrical characteristics of Alpeth (aluminum and polyethylene) plastic telephone cable are discussed in folder. Cable is used in aerial, duct, and direct burial applications. 4 pages. Rex Corp., Telephone and Control Cable Div., West Acton, Mass. B

Circle 623 on Page 19

Blower Units

Technical Data Sheets RX1 and RX2 on performance and dimensions of Radiax blower units respectively cover fan unit sizes up to 17 in. and up to 20 and 24 in. Performance curves for each unit size are provided. 2 pages each. Torrington Mfg. Co., Air Impeller Div., Torrington, Conn. D

Circle 624 on Page 19

Pressure Plugs

Levl-Seal flush-seating pressure plugs for hydraulic, pneumatic, or other high pressure systems are illustrated in descriptive Catalog 2501. Specifications are given for 1/16 to 1¼-in. sizes. 4 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 625 on Page 19

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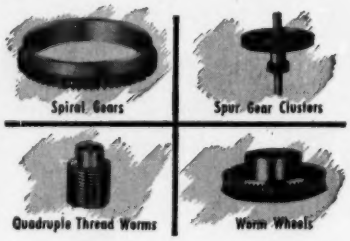
The production of custom-made, fine pitch precision gears is part of the daily routine at Boehme. Whatever your precision gear needs—up to A.G.M.A. precision #3, ⅛" to 5" O.D., 180 to 16 D.P.—our specialized engineering skills and excellence of craftsmanship produce the precision gears or gear trains that meet your specific problem.



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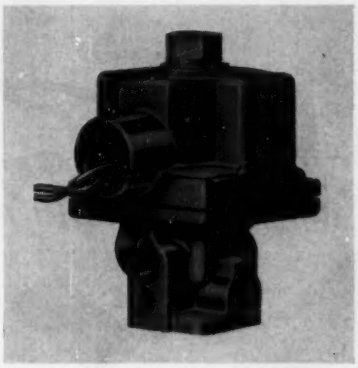
Circle 486 on Page 19

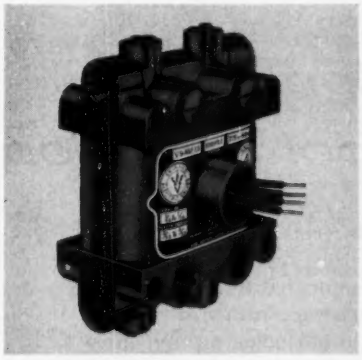
For versatile Cylinder Control, specify Skinner 3- and 4-way Solenoid Valves

For small cylinders . . . Skinner V5 and V10 air and hydraulic valves. Stainless steel construction. Mount in any position; can be cleaned without removal from line. Pressure ratings to 1000 psi. Available normally open, normally closed, directional control, multi-directional, quick exhaust. Orifice sizes: 3/64″ to 1/4″.

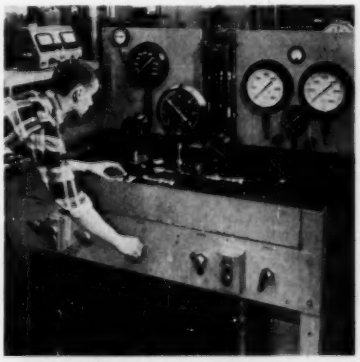


For medium cylinders . . . Skinner 3 way A Series valves. A new line that can also be used to operate smaller cylinders calling for increased cycling speeds. Die-cast, zinc body; stainless steel internal parts; mount in any position. Available normally open, normally closed, directional control. Pressure to 125 psi; orifice size, 5/32″.

Coming soon . . . for larger cylinders! A new-design, general purpose, high-flow industrial line of 3-way solenoid valves. These new valves will be available in orifice sizes of 3/8″, 1/2″ and 3/4″ and will be offered normally open, normally closed, or directional control in standard and explosion-proof construction. Operating pressures: 5 to 150 psi.



For double-acting cylinders . . . Skinner 4-way V9 valves. Two 3-way valves in one housing offered normally closed-normally closed, normally open-normally open, and normally closed-normally open. Available with adjustable flow features for exceptional cylinder control. Orifices: 3/64″ to 1/8″. Pressure ratings to 200 psi.



Exhaustive lab tests assure that you can use any Skinner valve with confidence. Built to the highest UL standards, Skinner valves are completely tested and checked to provide the best product available. Skinner's testing standards meet or surpass those of the aircraft industry.

A complete line of 2-, 3- and 4-way solenoid valves. There's a Skinner valve for almost any flow application with a wide variety of media: air, oil, water, inert gases, hydraulic fluids, kerosene and gasoline. Orifice sizes range from 3/64″ to 1″. Pressure ratings range from vacuum to 3000 psi. Explosion-proof models are UL approved for Class 1, Group D and Class 2, Groups F and G.

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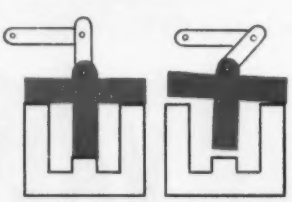
There may be solenoid application problems that we can't solve, but . . . we have yet to find one. It's simply because we are machine tool builders and fully understand the basic problems of converting electrical energy to mechanical energy. We've been at it for over 70 years. It's the reason why Namco solenoids have superior electrical and mechanical characteristics and why we can assure you of the one other factor that *truly* determines solenoid life...*proper application*.

Namco standard solenoids are available in a wide range of push and pull types. Custom-engineered solenoids in every size, capacity and type can be made to meet your specifications. Write us about *your* application problems stating specific requirements.

For Example:

Operating in an arc without proper linkage will cause incorrect seating of the plunger . . . allowing the solenoid to draw partial inrush current continuously. This will cause overheating and eventual malfunction of the solenoid.



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Circle 488 on Page 19

Motors & Drives

Characteristics and modifications for basic types of ac and dc standard motors, special motors, gearmotors, and adjustable speed drives are found in illustrated Bulletin 2650. They range from ¾ to 2000 hp. 8 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 626 on Page 19

Recorders & Controllers

Continuous self-standardizing strip-chart recorders and recording controllers for measurement of electrical and process variables are described in Bulletin GEA-6887. Instruments employ electronic servo-operated measuring systems. 12 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 627 on Page 19

Flow Rate Indicator

The 1842 Series industrial dual range flow-rate indicator described in Spec Sheet 51-1842A-1 receives two inputs from two turbine flowmeters. Flow rate measurement can be calibrated directly in volumetric or gravimetric units, or in per cent of maximum flow rate. 2 pages. Fischer & Porter Co., 150 Jacksonville Rd., Hatboro, Pa. E

Circle 628 on Page 19

Tapes, Resins, Connectors

"Insulate, Hold, Protect with Scotch Electrical Products for Industry" is an illustrated brochure which details pressure sensitive tapes, electrical connectors, insulation putty, splicing and casting resins, and tape dispensers. Application data are presented. 32 pages. Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. J

Circle 629 on Page 19

Vibration Recorder

Hand-held Vibrograph, an instrument which makes a tape recording of machine vibration amplitude, is subject of illustrated Bulletin K12A. Readings can be translated into terms of bearing or cutting tool wear. 2 pages. Korfund Co., 48-15-19D 32nd Place, Long Island City 1, N. Y. D

Circle 630 on Page 19

Rotary Selector Switch

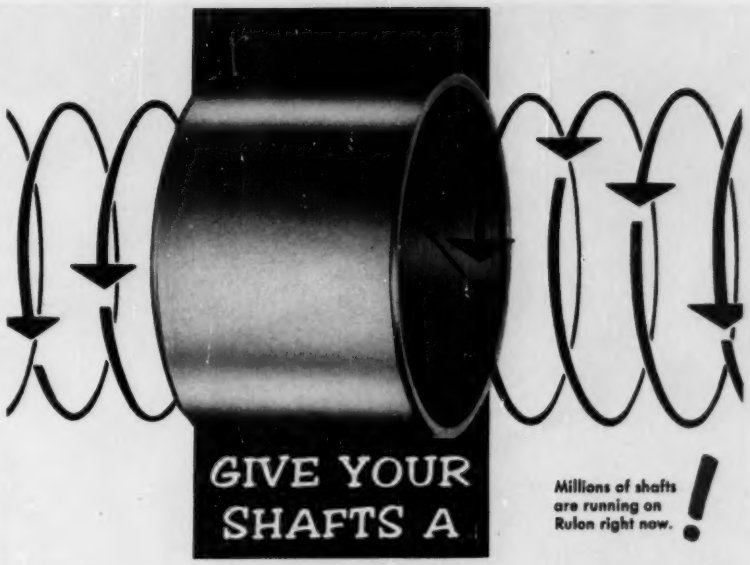
"Cock and fire" actuating mechanism and nontease circuitry are featured in the 28AS Series of rotary selector Micro Switches, described in illustrated Data Sheet 162. Ratings and specs are given. 1 page. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 631 on Page 19

Terminal Blocks

Various applications of heavy duty, medium duty, and sectional type Controlead terminal blocks are shown in descriptive catalog. Specifications and prices of all models are given. Marathon Electric Mfg. Corp., 12th & Cranberry Streets, Erie, Pa. K

Circle 632 on Page 19



FREE RIDE

on this low cost antifriction bearing

Dixon's T-Liner Sleeve Bearings . . . with antifriction "floating" Rulon® insert (modified TFE Teflon†) . . . are ready-built for installation in your designs. Available off the shelf in ten standard sizes, T-Liners give free riding, low friction performance on rotary or linear moving shafts.

These new bearings are recommended for PV values up to 10,000 *without lubrication!* (PV is the product of load on bearing in psi times rubbing speed in feet per min.) A thin Rulon insert within the metal shell . . . having extremely low coefficient of friction and 12 times the wear resistance of nylon . . . automatically adjusts itself to compensate for temperature changes. Unlike most plastics, Rulon is unaffected by moisture. Frictional heat is quickly dissipated through the liner and shell. Because of compactness and wide temperature adaptability (from sub-zero to 500°F), T-Liners answer many difficult space and environmental design conditions.

Besides eliminating lubrication, these bearings overcome problems of dirt, noise, and corrosion. They're lightweight, easy to install, and virtually maintenance-proof.

If your product incorporates rotating, reciprocating, or oscillating shafts, it will pay you to investigate Dixon T-Liners.

Engineering Data Sheet 32-T gives complete details. Write for your copy today.

DIXON CORPORATION
Bristol, Rhode Island

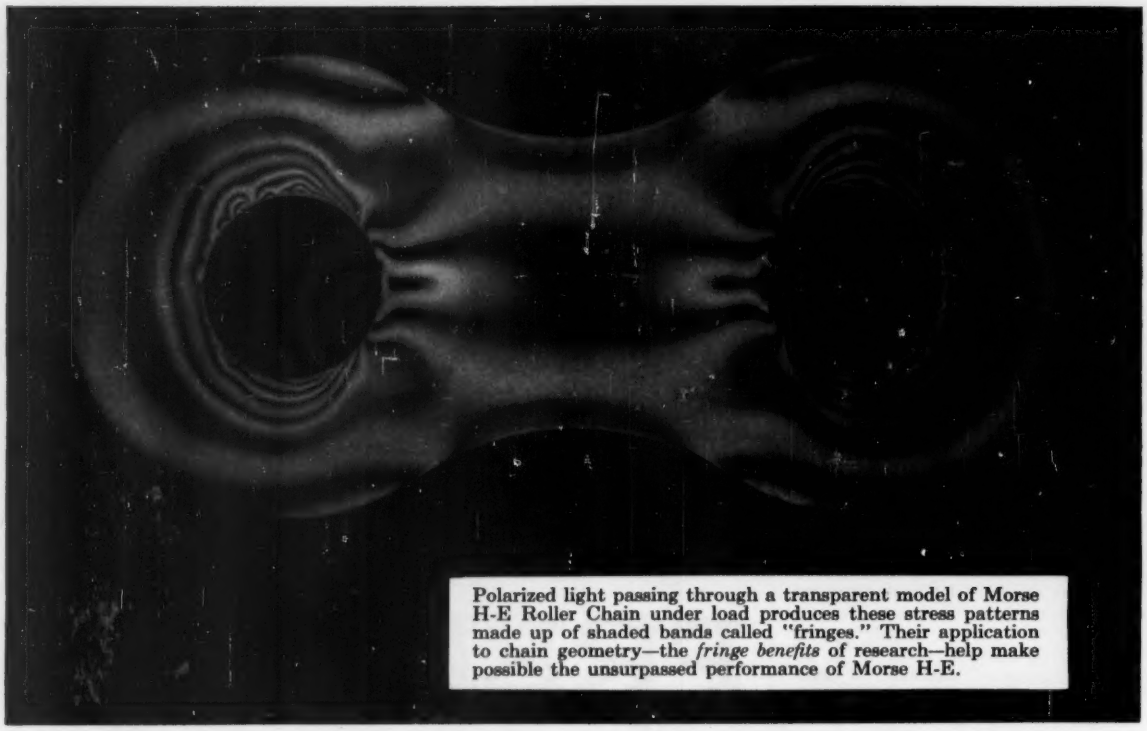
Standard Rulon T-Liner Bearings			
No.	ID in.	OD in.	Length in.
5201	¼	11/32	⅜
5202	5/16	⅜	⅜
5203	⅜	½	½
5204	½	⅝	½
5205	⅝	¾	⅝
5206	¾	⅞	¾
5207	⅞	1	⅝
5208	1	1⅛	1
5209	1⅛	1¼	1
5210	1¼	1⅜	1

†Du Pont TM

Dixon

suppliers of basic shapes and fabricated parts in Rulon and Teflon.

Circle 489 on Page 19



Polarized light passing through a transparent model of Morse H-E Roller Chain under load produces these stress patterns made up of shaded bands called "fringes." Their application to chain geometry—the *fringe benefits* of research—help make possible the unsurpassed performance of Morse H-E.

Photoelastic stress study shows . . .

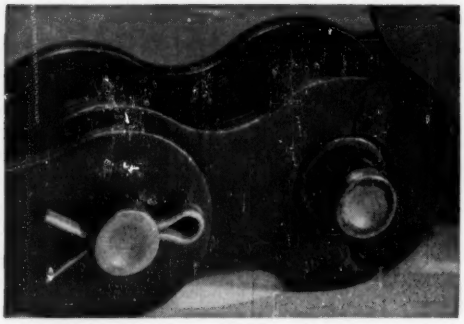
"FRINGE" BENEFITS MAKE MORSE H-E CHAIN LAST UP TO 5 TIMES LONGER!

Improved design . . . special mechanical and metallurgical processes give Morse H-E a 95% higher endurance limit

"Fringes"—the shaded bands which make up photoelastic patterns—show the intensity and distribution of stresses set up in a chain link-plate model under load. Morse engineers first use this knowledge to improve chain geometry. Then Morse production engineers apply advanced mechanical and metallurgical processes to side plates. Result: Morse High-Endurance Roller Chain, with up to 500% longer life under repeated heavy loadings.

Special treatment makes Morse H-E Chain cost about 10% more. Yet it pays for itself many times over in annual savings on replacement costs, lost production time and wasted man-hours.

For full information on research-developed Morse High-Endurance Roller Chain, write: Morse Chain Company, Dept. 6-69, Ithaca, N. Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.



ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit . . . outlasts ordinary chain by up to 5 to 1 under repeated loading.

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ONLY MORSE OFFERS ALL FOUR: Roller Chain, Silent Chain, Hy-Vo® and "Timing"® Belts

Epoxy Resins

Table of properties and application data on Araldite epoxy resins are found in illustrated Bulletin SW8091OM. They are used in high strength adhesives, surface coatings, troweling compounds, electrical embedding, structural laminates, and other products. 8 pages. Ciba Products Corp., Kimberton, Pa. E

Circle 633 on Page 19

Pressure Switches

Diaphragm, bourdon tube, and piston types of Meletron pressure switches are illustrated, described in detail, and presented with electrical and operating data in Catalog PS-59-60. Ordering chart, adjustment instructions, selection chart, and trouble-shooting and maintenance data are included. 36 pages. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 634 on Page 19

Welded Steel Tubing

Welded carbon and stainless steel tubing, subject of illustrated brochure, is available for a wide variety of applications. Its types, uses, manufacturing procedures, fabrication, and joining methods are covered. List of producers is included. 12 pages. Formed Steel Tube Institute, 850 Hanna Bldg., Cleveland 15, Ohio. G

Circle 635 on Page 19

DC Magnetic Brakes

Construction features of Type WB direct current magnetic brakes, available in six sizes for all 600 Series motors, are detailed in illustrated Bulletin 5000. Maintenance procedures and selection charts are included. 4 pages. Electric Controller & Mfg. Co., 4500 Lee Rd., Cleveland 28, Ohio. K

Circle 636 on Page 19

Torquemeters

Illustrated bulletin is descriptive of the Series 85 Torquemeter for measuring dynamic torques in the range of 5 to 250 oz-in. on shafts turning from 50 to 12,000 rpm. 2 pages. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo. K

Circle 637 on Page 19

Mercury Switches

Revised Catalog 90b describes the standard line of Honeywell mercury switches. Included are pictures, dimensions, electrical ratings, application information, and complete technical data. These controls give dependable, quiet, trouble-free services for thousands of control applications. 12 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 638 on Page 19

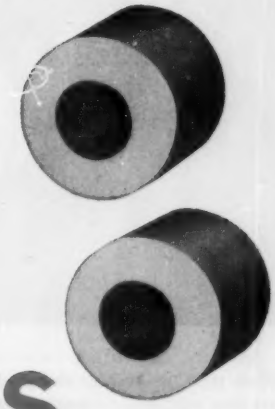
Aluminum Foil

Many and varied uses for aluminum foil in architectural, electrical, heating, cooling, printing, textile, industrial packaging, and other applications are featured in illustrated Form 20-11206. 24 pages. Aluminum Co. of America, 782 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 639 on Page 19

TEFLON,* KEL-F† MOLDED PARTS COME IN

PRICE RANGES



One is the cost of a *perfect* piece. The other is the cost of an *acceptable* piece.

Garlock's Plastics Division, The United States Gasket Company, will quote both ways. If you require perfection in every sense, then U.S.G. will furnish it. If "leeways" in tolerance or mold finish, for instance, are permissible, then U.S.G. can possibly suggest ways to save 20-25% of the total cost of a molded piece.

Guarantee yourself the right price and right quality every time. No matter how intricate the shape, how thin the wall sections, or how close the tolerances, ask your local Garlock representative to quote on your molded Teflon or Kel-F parts. Call him, or write.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.
For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

*DuPont Trademark for TFE Fluorocarbon Resin
†M.M. & M. Trademark

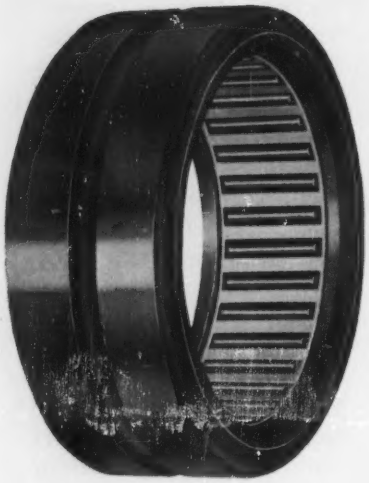
United States Gasket

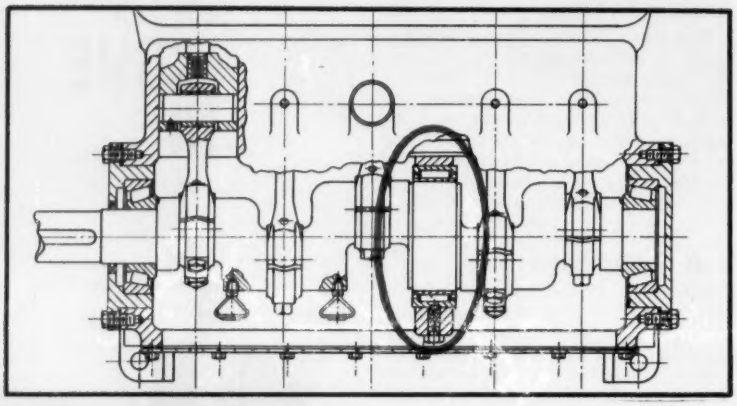
Plastics Division of GARLOCK

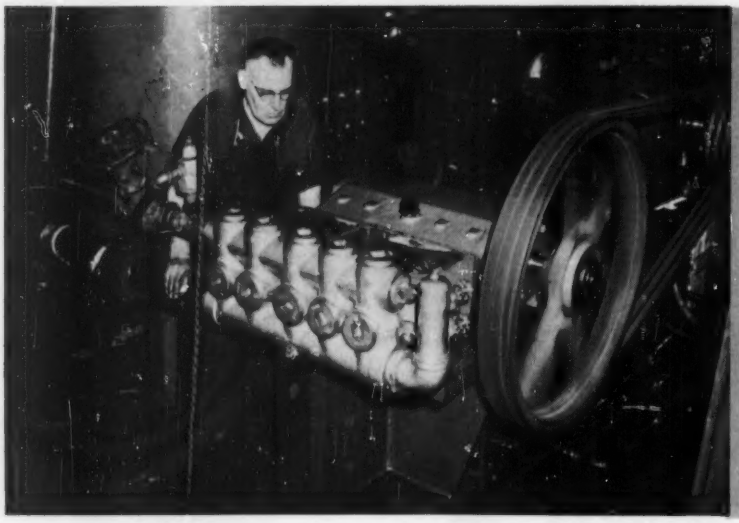
Circle 491 on Page 19

ORANGE *Cage Type* NEEDLE BEARINGS

selected for Center Main Bearing in Crankshafts of WORTHINGTON HORIZONTAL QUINTUPLEX PLUNGER PUMPS







ADVANTAGES GAINED

- **Non-skewing roller action**
- **Ease of assembly**
- **No adjustment necessary**

Cutaway of crankshaft section of Worthington Horizontal Quintuplex 5-Plunger Pump, shows installation of 8" O.D. Orange Cage Type Needle Bearing, with special I.D. inner race. It produces an efficiently designed bearing to maintain rigidity of the crankshaft.

With the Orange cage design, precision needle rollers are positively and permanently aligned along the entire length of the roller periphery. The rollers resist skewing, even under conditions of overhung mountings—shaft deflection—misaligned housings—vertical mountings—uneven loading.

As a result, Orange Cage Type Needle Bearings are extremely quiet and even-running, with low internal friction. You can design to gain the high load-small space advantages of needle bearings in a broader range of application.

Orange Cage Type Needle Bearings are available in all standard sizes from ½" to 9¼" shaft diameters. Sealed types in 24 sizes from ½" to 2"; also separate cage-and-roller assemblies (without races) to meet extreme space restrictions.

Write for new 48-page Engineering Reference Manual giving specifications on all Orange Cage Type and other Orange Roller Bearings.

ORANGE
ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

High Pressure Seal System

O-Seal fittings for 5000 psi and temperatures up to 275° F can be used in any type of high pressure piping system containing water, oil, or gas. Described in illustrated Catalog 59 are globe, angle, check, and relief valves; union and coupling nuts, tailpieces, adapters, plugs, and other fittings incorporating the seal. Specs are included. 20 pages. Combination Pump Valve Co., 851 Preston St., Philadelphia, Pa. E

Circle 640 on Page 19

Plastic Mill Shapes

Mill shapes of Polypenco Penton chlorinated polyether resins now available are detailed and illustrated in Bulletin BR-6. Rod, strip, tubing, tubular bar, plate, tank linings, pipe, special castings, fabricated parts, and coatings are covered. Suggested uses and properties are given. 4 pages. Polymer Corp. of Pennsylvania, 2140 Fairmont Ave., Reading, Pa. C

Circle 641 on Page 19

Reactor Metals

Forms, sizes, and other data on such reactor metals as boron-stainless steel alloys, hafnium, niobium, tantalum, vanadium, zirconium, and zircaloy are presented in Bulletin IND-20. Specifications, tolerances, and thickness ranges are included on these materials in sheet, strip, foil, wire, seamless tubing, clad, and alloy forms. 8 pages. Metals & Controls Corp., General Plate Div., Attleboro, Mass. B

Circle 642 on Page 19

Air Compressors

Designed for nine out of ten compressed air applications, Model 3-AT compressors are horizontal, water cooled, single stage machines. Full specifications of these machines which have displacements up to 2200 cfm are given in Bulletin 350. Pressures range to 150 psi. 8 pages. Pennsylvania Pump & Compressor Co., Easton, Pa. G

Circle 643 on Page 19

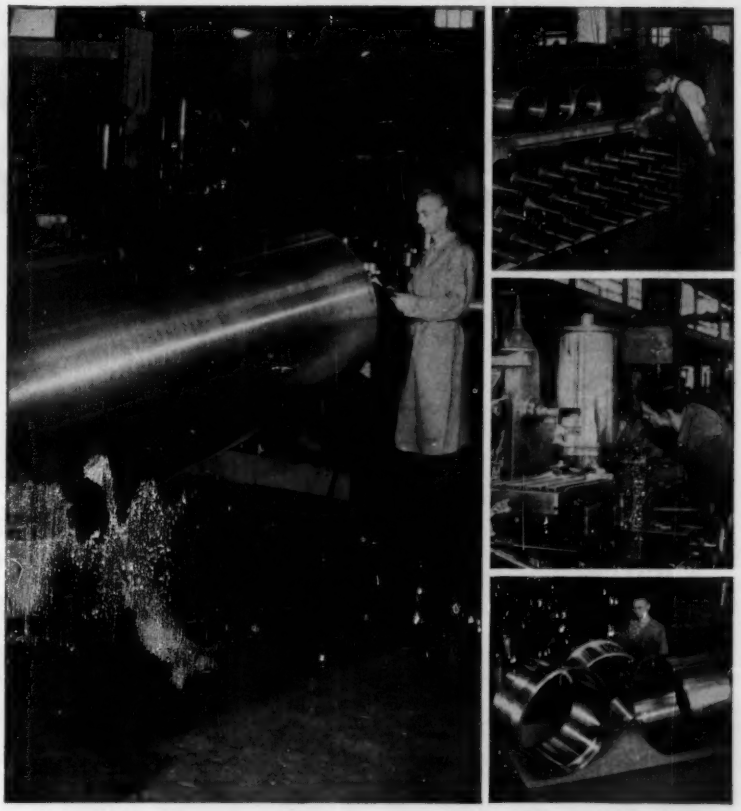
Stock Plastics

Plastic sheets, rods, tubes, films, and special shapes as stocked in warehouses in major industrial centers are listed in 1959 catalog. Also detailed are cements, pigments, and miscellaneous supplies. Full information is given, including properties of acetate, acrylic, butyrate, Implex, Kel-F, Mylar, nylon, phenolic, polyethylene, polystyrene, Teflon, high impact styrene, and vinyl in cast, extruded, molded, and laminated shapes. 64 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 644 on Page 19

Sprockets & Chains

Comprehensive stock Catalog No. 60 presents details on 1300 different stock sprockets and various types of roller chains. Technical data and chain drive engineering information are included. 88 pages. Write directly to Cullman Wheel Co., 1344 Altgeld St., Chicago 14, Ill. J



You'll find them better for pressure if they're

SHENANGO CENTRIFUGAL CASTINGS

WHATEVER the inside or outside pressures, Shenango centrifugal castings are better able to withstand them without failure.

Parts cast by the Shenango centrifugal process are much tougher because their finer, *pressure-dense* grain avoids stress concentrations while providing greater strength, better elongation and freedom from such costly defects as sand inclusions, blowholes and such.

Whether you need rings, rolls, sleeves, liners, bushings, bearings, mandrels or *any* annular or symmetrical part . . . ferrous or non-ferrous . . . in whatever shape, size or dimension to meet your requirements . . . Shenango can do the job. And do the job *better!*

For informative bulletins on the answers to your tough problems, it will pay you to write now to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, O.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

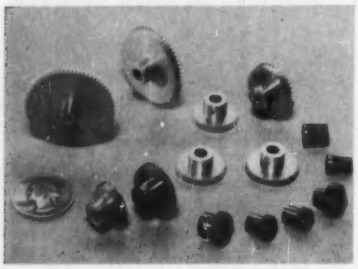
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Precision Gears

solid-hub types are available in five bore sizes

Available in stainless steel and anodized aluminum, solid-hub gears have diametral pitches of 48 through 200, with consecutive tooth selection from 20 to 120 teeth. Gears meet AGMA Precision Class 1 and 2 tolerances, and are available in



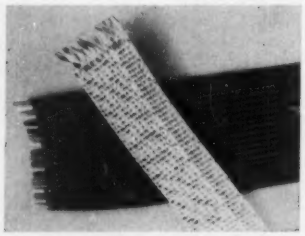
0.12, 0.125, 0.1875, and 0.25-in. bore sizes. **U. S. Gear Corp.**, 81 Bay State Rd., Wakefield, Mass. B

Circle 645 on Page 19

Multiconductor Cables

in flat configurations are extremely flexible

For use in specialty and tight locations, multiconductor ribbon cables are extremely flexible in one plane. Applications for the high-temperature cables include running them around corners or around inside edges of a container. They are also useful with drawer pull-out type printed-circuit assemblies. Wires lie lengthwise in ribbon cable. Interlocking or weaving of yarns binds wires in place. Yarns include Teflon, nylon, glass fiber, Dacron, and cotton. Metallic "woofs" such as silver-plated copper, tinned copper, and stainless steel are also available. Primary insulation of wire is either Teflon or PVC. Any number of twisted multiconductors, co-axial cables, and single conductors as small as 36 AWG can be used. Individual wires need not be of the same gage. **Tensolite Insulated Wire Co. Inc.**, West Main Street, Tarrytown, N. Y. D



Circle 646 on Page 19

Stainless-Steel Honeycomb

high-temperature material has high resiliency

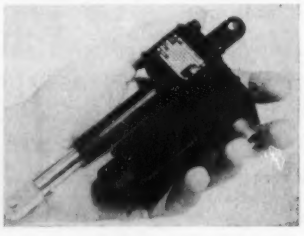
Condition C welded stainless-steel honeycomb with high resiliency offers excellent resistance to damage and abuse. It has a metallurgically superior weld and superior surface finish. Cell sizes of the honeycomb are 3/16 and 1/4 in. in gages of 0.001, 0.0015, and 0.002 in. Alloys available include PH15-7MO, 17-7PH, and AM 350. Material has applications in air and space craft. **Hexcel Products Inc.**, 2332 Fourth St., Berkeley 10, Calif. M

Circle 647 on Page 19

Linear Actuator

miniature unit handles loads to 400 lb

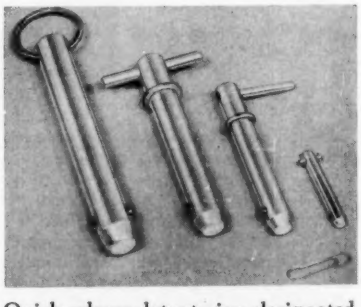
Lightweight miniature linear actuator incorporates a long-life slip clutch to eliminate limit switches. Available in various combinations of speeds and strokes, it handles loads to 400 lb. Envelope is 1 3/8 in. wide by 3 in. high by 5 3/4 in. long, and weighs approximately 1 lb. Flat-side housing is a one-piece extrusion readily adaptable to gear-ratio changes and addition of other components. Choice of motor positions is available, and it is possible to add position indicators, synchros, or flex-shaft take-off in various positions. Adjustable slip clutch absorbs inertia of motor rotor when unit contacts its nonjamming torsional stops at extend and retract positions. It also provides overload protection when an excessive load is imposed on actuator. **Lear Inc.**, P. O. Box 688, Grand Rapids 2, Mich. H



Circle 648 on Page 19

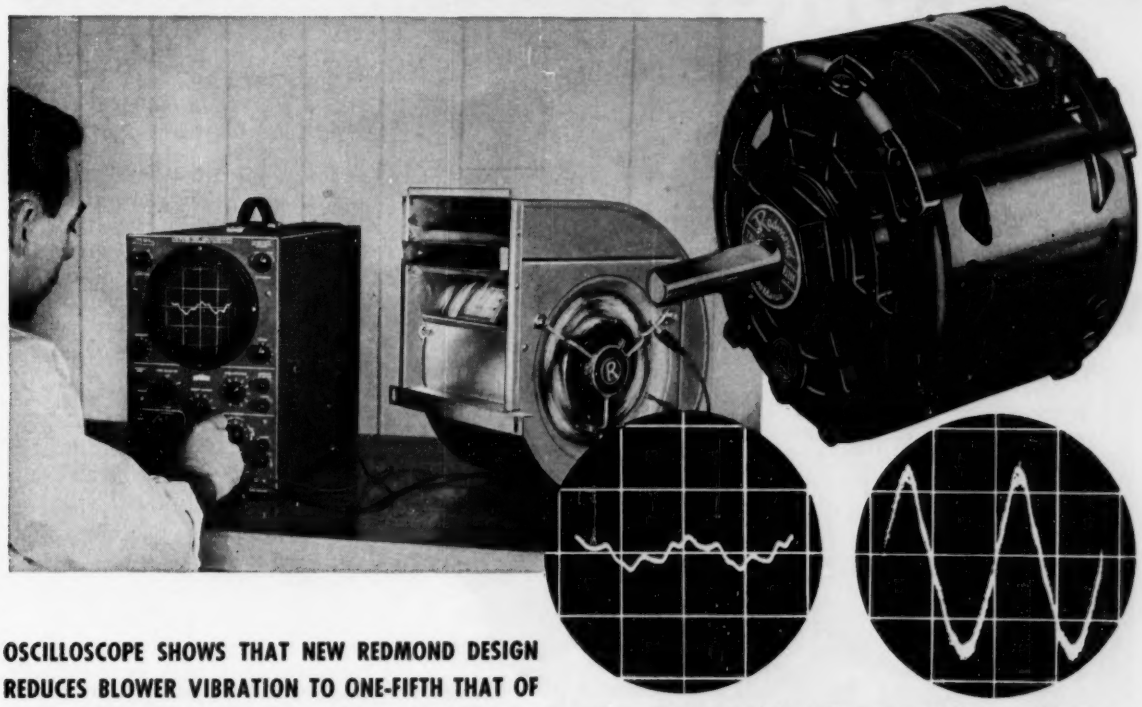
Detent Pins

quick-release units are self-retaining



Quick-release detent pins, designated Faspins, secure assemblies or mechanical units at points of frequent assembly or disassembly. They also provide a fastening device that can be withdrawn immediately for emergency release. Pins are top-quality steel, and have high shear strength and surface hardness. They are available with T or L-type handles or grip rings in a wide range of sizes from 3/10 to 12 in. long

New *Redmond* Motor Is Quietest For Direct Drive Blowers



These photographs of the oscilloscope screen show the reduction of vibration in the blower when the Redmond Type AY Micro-Motor is used. The photo at the left shows blower vibration with the Redmond AY; the one at the right shows vibration with a competitive motor.

OSCILLOSCOPE SHOWS THAT NEW REDMOND DESIGN REDUCES BLOWER VIBRATION TO ONE-FIFTH THAT OF UNITS USING CONVENTIONAL SHADED-POLE MOTORS

You can see for yourself on the oscilloscope screen that the Redmond Type AY MicroMotor reduces blower vibration to only one-fifth that of competitive motors running in the blower. Whether you test with vibration testing equipment, a mechanic's stethoscope, or an oscilloscope, you will conclude that the AY is the quietest direct-drive blower motor available. Use it to solve the problem of vibration in your blowers.

The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The Tri-Flux design adds a third flux path, making possible a larger diameter shaded-pole motor that is more efficient and has higher starting and running torque than conventional shaded-pole motors. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

The new AY is ideal for a wide variety of applications requiring a quiet, economical, quality motor. Redmond sales engineers are skilled technicians whose primary function is applying a motor to your product. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once. See your telephone book for locations of sales offices in Cincinnati; Cleveland, Dallas; Newark; El Segundo, California; and Oak Park, Illinois.

NEW CATALOG

New 12-page catalog describes and illustrates basic line of Redmond fractional horsepower electric motors, blowers, and special products. Send request for your free copy to Redmond Company, Inc., Owosso, Michigan.

The Standard of Dependability

CC Redmond COMPANY, Inc.

Subsidiary of CONTROLS COMPANY of AMERICA

OWOSSO, MICHIGAN

THE BIG NAME IN SMALL MOTORS

ESCO CENTRIFUGAL CASTINGS KEEP

MACH 17 IN A TUBE!

Tremendous pressures and temperatures are generated in this shock tube at Lockheed Aircraft Corp., to simulate conditions encountered by a long-range ballistic missile re-entering the earth's atmosphere. High pressure gas triggers shock waves which travel 17 times the speed of sound. Instantaneous temperatures range above 15,000 degrees F.

The 44-foot long tube is an assembly of *ESCO* heavy-wall Spuncast® castings hydrostatically tested at 10,000 PSI. It is typical of the many exacting casting jobs that wind up at *ESCO*.

Simplify your design problems by calling *ESCO* for special alloy steel Spuncast pipe, standard heavy wall fittings, and special design fittings and valves.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY

2183 N. W. 25TH AVE. • PORTLAND 10, OREGON

MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

Offices in Most Principal Cities

ESCO INTERNATIONAL, NEW YORK, N. Y.

IN CANADA ESCO LIMITED

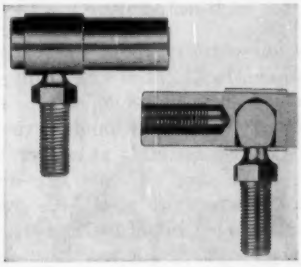
and 3/16 to 1 in. diam. Applications include construction, farm equipment, industrial, marine, military, and automotive uses. Aerofast, P. O. Box 324, Wheaton, Ill. I

Circle 649 on Page 19

Ball Joints

have long life and excellent shock resistance

SP Series ball joints incorporate a redesigned ball which departs from conventional spherical shape and which has a shorter, heavier neck. Movement is free at any point in a minimum conical angle of 30 deg, regardless of plane of deflection. Female part of joint consists of joint



body and a spring-steel retaining sleeve. Spring-loading mechanisms, end screws, and cotter pins are eliminated. Shear strength is increased by 29 per cent increase in neck diameter. Units have long life and excellent shock resistance. **Superior Ball Joint Corp.**, 8939 Trier Rd., Ft. Wayne, Ind. J

Circle 650 on Page 19

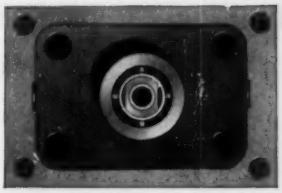
Spring Motor

retracts or counterbalances light loads

Small mechanical motor is powered by a fully enclosed spiral-type spring capable of producing a relatively constant output torque throughout long deflection. It is useful in applications requiring constant but small retracting forces over long deflections with minimum force build-up. Outer rim of spring case serves as a pulley for a stainless-steel cable through which motor torque can be applied as a linear force. Maximum extension of cable is 5 ft, and force exerted on it by spring varies from 12 oz at full extension to 7 oz when fully retracted. Mounted on a black plastic case, Spir'ator motor

YOUR BONUS from Pathon HYDRAULIC CYLINDERS

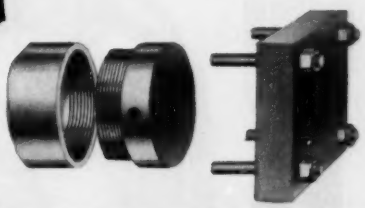
For the Designer



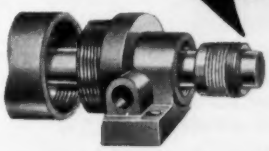
Pathon's compact design saves valuable space, makes your designing job easier, and gives your equipment that modern, rugged look.

For the User

Pathon's screw thread head design gives you up to 40% more strength than most tie-rod cylinders. This increased strength means less maintenance, and longer life.



For the Maintenance Man



Rod packing and bearing is externally replacable and any part can be replaced without complete disassembly and the resulting "basket full of parts".

FOR YOU

Let us give you a "Rod Column Effect" calculator. From this easy-to-use slide rule obtain optimum rod diameter for a given load and stroke.

Write for Calculator and Bulletin No. 22-A

Pathon MANUFACTURING COMPANY
3823 PACIFIC AVE. • CINCINNATI 12, OHIO

B-59

FLUID OPERATED AND CONTROL EQUIPMENT

NOW AVAILABLE

STRATOFLEX

FLARED TUBE TYPE ELBOW FITTINGS AND ASSEMBLIES

For confined space installations where hose fittings of minimum dimensions are required

For complete information, write for Bulletin S-4 today.

Installation of hose assemblies in a confined space has long been an industry problem. To solve this problem, Stratoflex has developed a flared tube series of elbow hose fittings and assemblies.

Use of these Stratoflex assemblies eliminates the need for combinations of fittings and elbow adapters.

- Form tubing used for fabrication of fittings to allow uniform flow.
- Fittings available for medium and high pressure applications and for transmission of all fluids.
- All fittings are quality steel, quality controlled in manufacture.

BFS-9

STRATOFLEX Inc.

P.O. Box 10388 • Fort Worth, Texas
Branch Plants: Los Angeles, Fort Wayne, Toronto
In Canada: Stratoflex of Canada, Inc.

SALES OFFICES:
Atlanta, Chicago
Cleveland
Detroit, Fort Wayne
Fort Worth
Houston, Kansas City
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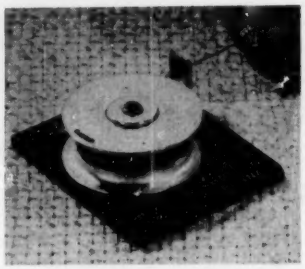


assembly is 2 in. wide, 2⅜ in. long, and 11/16 in. high. **Spir'ator Div., Hunter Spring Co., Div., American Machine & Metals Inc.**, 1 Spring Ave., Lansdale, Pa. E

Circle 651 on Page 19

Epoxy Resin

for high-temperature use

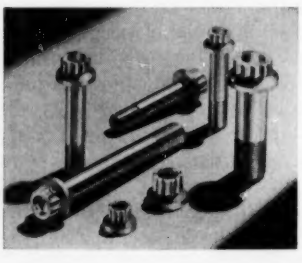
A low-viscosity epoxy impregnating system, Isofil 211 is specifically conceived for high-temperature use. Cured resin withstands extended periods of operation at temperatures to 500 F, and exhibits heat-distortion temperature of 370 F. System has working life of two weeks, making it suitable for use in vacuum-impregnating and laminating operations. Resin displays excellent adhesion, high-grade electrical properties, complete moisture resistance, and stability toward chemical attack. **Isochem Resins Corp.**, 221 Oak St., Providence 9, R. I. B

Circle 652 on Page 19

High-Strength Fasteners

have tensile strength of 260,000 psi

Companion steel bolts and self-locking nuts, designated EWB 26 and FN 26 respectively, are furnished in No. 10 through 1¼ in. diam size. They have minimum tensile strength of 260,000 psi. The 12-point external wrenching bolts and nuts have exceptional fatigue performance. Bolts are fabricated



Circle 497 on Page 19

NEW BOOKLET

helps you choose the RIGHT motor for better machine tool performance

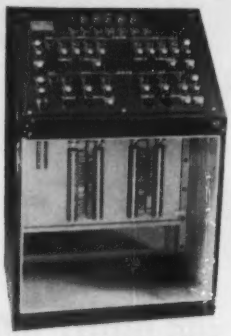
There are many vital factors to be considered in selecting
THE RIGHT MOTOR for a Machine Tool
MOTOR SELECTION and
TORQUE CHARACTERISTICS

write today
for your free copy

It's just off the press—and filled with information that may help you improve your products! What are the factors involved in proper motor selection? How can you specify motors that will deliver all the speed, precision and performance you build into your machine tools? What are the engineering features that guarantee dependable operation and long motor life? This book tells you. Send today for "THE UNDERCOVER STORY . . . What to Look for under the Frame in Motors for Machine Tools."

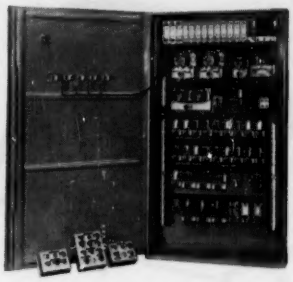
MARATHON ELECTRIC

MARATHON ELECTRIC MANUFACTURING CORPORATION
Wausau, Wisconsin



Operating console used in automatic control of drying system. Control Panel Corporation also builds the custom-made cabinets.

Motor controller manufactured for the Navy under prime contract. Qty 107. All major operating components meet Navy "A" High Stock requirements. Assembly-line produced on sub-assembly basis.



This panel automatically controls newsprint paper conveyor at three stations. Controls include electric switching of conveyor routes. Entire system governed by interlocking photoelectric safety relays which prevent paper from bunching or running off conveyor terminals.

2 miles of wire in this free standing control panel for controlling "Detroit Type" transfer machine. Constructed to meet JIC Specifications. Used by automotive company in the manufacture of connecting rods. Completely wired and interconnected for checking before taking down for shipping.

Here's where *Reliable, Compact* Automatic Control Panels *Cost You Less!*

Whether it's design *and* assembly—or assembly to your existing design . . . Control Panel Corporation can guarantee reliable, compact control panels at less cost. And we can *meet* your due date.

This is possible simply because panel manufacturing is our *only* business. Our efficiency is high—so your cost is naturally lower. Furthermore, Control Panel Corporation provides the custom-made enclosures you want at prices competitive with ordinary stock enclosures. That's why scores of companies, big and small, keep coming back to Control Panel Corporation.

Best way of showing our potential use to you is by submitting our quotation or proposal covering your requirements—be it one thousand panels or one. There is no obligation, of course.

ASK FOR NEW BULLETIN

Lists Pantro uses and Pantro users. Shows a cross-section of the many types of automatic control panels. Pantro has designed or built for industry of all kinds.

Pantro

CONTROL PANEL CORPORATION
517 W. Monroe St. • Chicago 6, Ill.

A Partial List of Pantro Uses:

- Bakery machinery
- Canning machinery
- Cement and clay working machinery
- Chemical machinery
- Confectionery and ice cream machines
- Construction and road-building machinery
- Flour, grain mill machinery
- Food products machinery, misc.
- Foundry machinery
- Machine tools
- Metalworking machinery
- Oil field machinery and tools
- Paper industries machinery
- Plastics molding machinery
- Printing trades machinery and equipment
- Rubber working machinery
- Special industry machinery
- Textile machinery
- Woodworking machinery
- Conveyors and conveying equipment
- Cranes, hoists, derricks
- Furnaces and ovens, industrial
- Hydraulic equipment, including pumps and controls
- Internal combustion engines
- Packaging and labelling machinery
- Locomotives and parts
- Railroad and steel cars and equipment
- Communications equipment
- Electronics equipment
- Motors, generators, motor generator sets

from 5 per cent chromium high-strength steel of VascoJet 1000 type, and are cadmium plated. Nut provides compatible tensile strength and high fatigue life with minimum mass of material. Bolt thread has large, controlled root radius that increases fatigue and temperature performance. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 653 on Page 19

Electrical Lug

has indicating screw for proper compression

Accommodating a wide range of conductor sizes, Reddy Lug is for use with either aluminum or copper conductor. Sealed-in cable compound and indicating screw provide fast, reliable installation. Bared,

cleaned conductor end is inserted into wire bore in which cable compound has been factory-applied. Compression screw is tightened until appropriate marking on screw matches with cable size, indicating correct degree of tightness. Plastic handle wrench, the only installation tool needed, is included in each standard package of lugs. Lug, which has one bolt hole, is available in four sizes to handle wire range from No. 8 to 500 MCM. Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. D

Circle 654 on Page 19

Revolution Counter

four-digit unit is tamper resistant

Knob-reset, four-digit, add-subtract counter is 1¾ in. wide, 2¾ in. long, and 1½ in. deep. Top-coming shaft revolutions add ten counts, reverse revolutions subtract

RBC

Heavy duty

SELF-ALIGNING BUSHING ASSEMBLIES

. . . for industrial and aircraft applications where misalignment tends to exist with high static loads or intermittent oscillation under load.

LONGER LIFE of the RBC Self-Aligning Bushing is the result of precision ground and hardened (60-63 Rockwell C.) bearing surfaces on both the outer race and the ball. Axial fracture of the outer race after it is precision ground and hardened permits insertion of the ball, eliminates dirt and grit collecting pockets, provides more efficient lubrication control. Recessed snap ring maintains integral unit for ease of assembly. RBC Self-Aligning Bushings are made of SAE 52100 steel and coated with molybdenum disulphide.

• For help in removing the "MIS" from your "MISalignment" problems consult the RBC Engineering Department or . . .

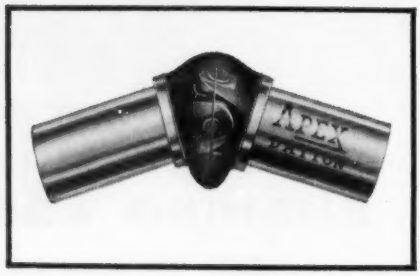
AD 1158

Write for Bulletin SF-86.

ROLLER BEARING COMPANY OF AMERICA
Sullivan Way, West Trenton, N.J.

Circle 500 on Page 19

APEX
covered
universal
joints
may solve
your drive
line problem!



If your drive line design problem involves operation in wet or dry, corrosive or abrasive atmospheres, or even extremes of temperatures, Apex *covered* universal joints may offer a solution.

On marine applications, for example, Apex *covered* universal joints operate efficiently in stagnant sea water! Salt water corrosion is sealed OUT—clean, sustained lubrication is sealed IN.

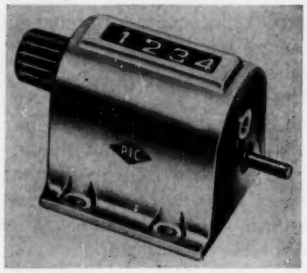
The sealed, lubricant-retaining cover is just one of several exclusive Apex design features that have improved standard universal joint applications and have created new applications never before feasible.

SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Data Sheet.

THE APEX MACHINE & TOOL CO.
1942 South Patterson Blvd.
DAYTON 2, OHIO

Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperatures.



ten counts, with speeds to 12,000 cpm. One complete turn of knob resets to zero. Mounting holes in one-piece cover of the tamper-resistant unit prevent disassembly without dismounting counter. **PIC Automation Controls Div., General Controls Co.**, 8062F McCormick Blvd., Skokie, Ill. J

Circle 655 on Page 19

Ceramic Wire Insulation

has rating of 1000 F for continuous operation

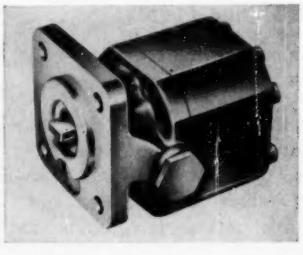
Flexible, high-temperature, ceramic-wire insulation has been coated on wire 10 mils and greater in thickness. Designated Durock, material has a temperature rating of 1000 F for continuous operation. Aluminum, nickel-clad copper, Chromel, Alumel, and Constantan are available as conductors. Material is wound on mandrels five times the diameter of the wire. Advanced dielectric strength is achieved, with thickness of 0.6 mil of ceramic yielding 400 v dc resistivity. **Technical Industries Corp.**, 389 N. Fair Oaks Ave., Pasadena, Calif. L

Circle 656 on Page 19

Piston Pump

has built-in charging gear pump

Low-cost piston pump measures 3½ x 3¾ x 3½ in. and weighs 5 to 6 lb. Gear section is rated ½ gpm at 1800 rpm for charging, and



Circle 501 on Page 19

up to 8 gpm is available for other work. Various piston diameters provide from 10 to 50 cu in. per min at pressures to 4000 psi. Unit mounts in any position, and has direct, belt, gear, or special drives. It can be used for small-volume, low-pressure, small-volume, high-pressure, or dual-volume, dual-pressure applications. **Constant-Flo Div., John S. Barnes Corp.,** 301 S. Water St., Rockford, Ill. K

Circle 657 on Page 19

Plastic Screw

incorporates serrated metal core

Insul-Screw consists of a serrated metal core with threaded plastic body. Metal core carries torque applied by driving means and eliminates danger of breaking or distort-

ing head. Standard materials are nylon and steel, with other plastics and metals available for special applications. Screw is self-insulating, self-locking, eliminates vibration and corrosion, and is chemically inert. It is supplied in a wide range of colors for coding or decorative purposes. **Austin Screw Products Co.,** 4873 W. Armitage Ave., Chicago 39, Ill. J

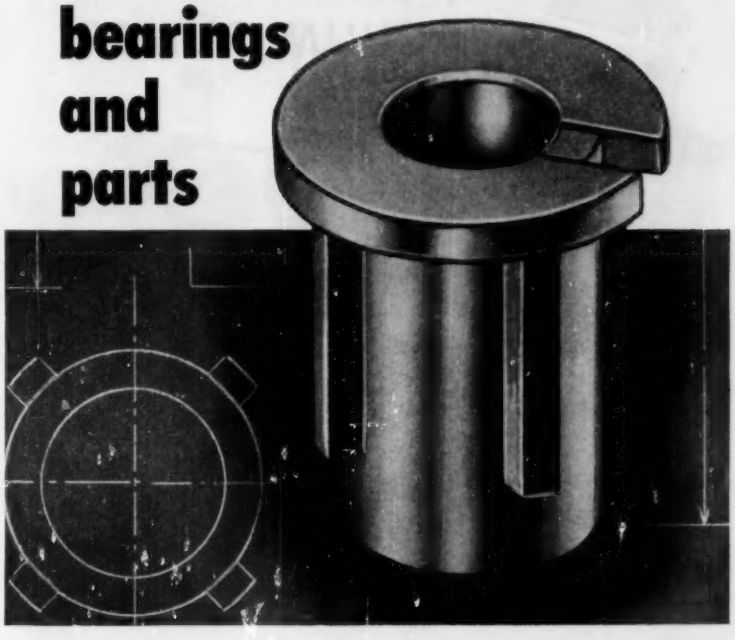
Circle 658 on Page 19

Ball Bearings

miniature units have redesigned inner ring

Design change in inner ring of ball bearings (right) provides an effective shield that reduces by as much as 70 per cent the size of dirt particles which can get into bearings. There are no corners where dirt and dust can collect to cause drag between shield and inner ring, and full thickness on side of inner ring provides broad reference surface for

Bunting makes the "almost impossible" bearings and parts



The photograph shows a sintered bronze bearing used in an exceedingly popular home laundry drier. It offers several unusual features, some of which you may find useful in designs you are considering as sintered parts. In the first place because the splines on the O.D. of the bearing abut the back of the bearing flange, this is a part which would be almost impossible to produce by machining but can readily be produced by powder metallurgy.

Second, the splines do not extend the full length of the bearing but the density of the splines must be the same as the remainder of the bearing. This requires intricate and unusual tooling and understanding of the problem which is one of the reasons why this manufacturer put his design in the hands of Bunting.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze, sintered metals or Alcoa aluminum, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

The Bunting Brass and Bronze Company
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Bunting®

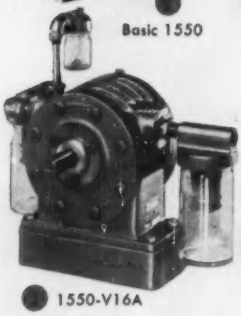
BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS. ALCOA® ALUMINUM BARS

Circle 502 on Page 19

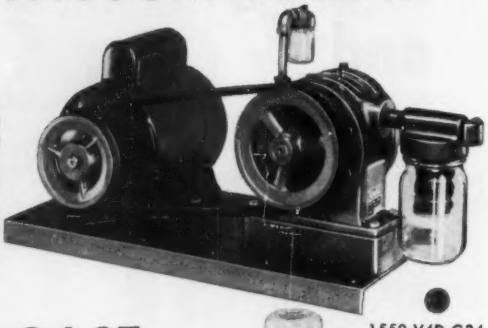
Basic 1550

Need an original equipment VACUUM PUMP?

GAST



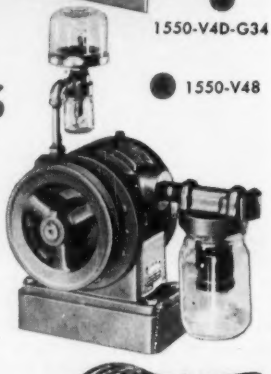
1550-V16A



1550-V4D-G34

SEE HOW GAST CUTS YOUR COSTS

1550-V48



These pictures demonstrate how *your* product —and cost budget—may benefit when you select Gast rotary Vacuum Pumps for original equipment.

Above (1) is a basic Model 1550 less accessories (one of 13 sizes). For current, active customers, Gast builds this model in dozens of variations. Each one meets specific needs for vacuum, pressure, lubrication, drive method and type of service.

For example, (2) is equipped with wick oiler, and intake and outlet filters for both vacuum and pressure used on paper feeding applications. (3) includes fan-pulley, belt, motor and base as sold for intermittent operation on vacuum-back cameras, vacuum chucks and plastic sheet forming units. (4) has new, large constant-level oiler for rigorous industrial duty. (5) *never* needs oil—has carbon vanes for oil-free air. (6) is a 1550 Model Air Compressor with air intake filter.

As you see, each original equipment buyer gets a job engineered pump. *In the same way, you can save money, because Gast ingenuity—and tooling and manufacturing efficiency—permit precision quality at production prices.*

1550-V105

1550-P41A
Air Compressor

WRITE FOR FULL DETAILS—REQUEST CATALOG

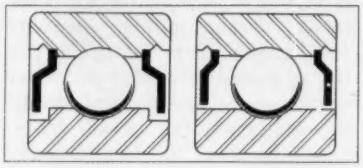
GAST MANUFACTURING CORP., P.O. Box 117-P Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE OR FLUID POWER DIRECTORY

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"



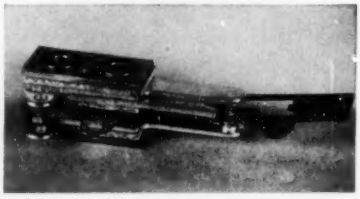
mounting. Gap between shield and inner ring has been closed to 0.002 in., or less than one-third that of previous shielding. Close tolerance is made possible by fitting shield to precision-ground OD of inner ring. **New Hampshire Ball Bearings Inc.**, Grove Street, Peterborough, N. H. B

Circle 659 on Page 19

Snap Switch

incorporates contacts with wiping action

Moving contact in open-blade snap switch has a slight lateral movement. Moving contact wipes across stationary contact so that small electrical welds caused by electrical



arcing are broken, permitting contact break. Switch has conservative rating of ½ hp or 15 amp, 125 v, resistive load. **Columbus Electric Mfg. Co.**, 2005 E. Main St., Columbus 5, Ohio. G

Circle 660 on Page 19

Silicone Grease

lubricant is chemically inert

Silicone grease, designated SS-4007, maintains consistency from −75 to +300 F. Chemically inert, it is designed as a rust inhibitor and lubricant for mated, threaded, or nonthreaded ferrous components and fabricated rubber parts. Primary applications include use as a high and low-temperature thread lubricant, corrosion-preventive compound, and as a rubber lubricant for low and medium-swelling components such as O-rings. Grease meets requirements of military specification MIL-C-21567. Compound

Circle 503 on Page 19

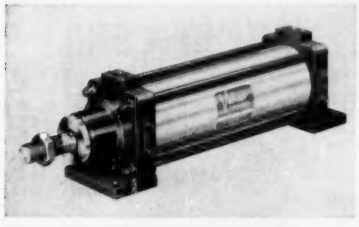
also offers good storage stability and ease of application. Silicone Products Dept., General Electric Co., Waterford, N. Y. C

Circle 661 on Page 19

Heavy-Duty Cylinders

for use on high-production machinery

Air and hydraulic cylinders are built to JIC standards for use on automated and other high-production machinery. Extra-long bronze rod bearing, with length-to-rod



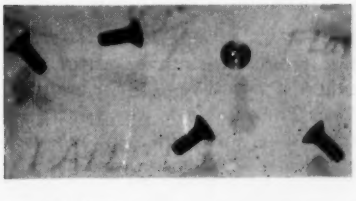
diameter ratios of up to 2:1, provides maximum rod stability and resistance to side-loading deflection. Rod wiper and metallic-backed rod seal are installed in a removable cartridge which can be replaced without partially disassembling cylinder. Wide Teflon wear strip on piston prevents metal-to-metal contact between piston and bore. Nylon retainer-spacers in piston U-cups for air applications, or Teflon-backed O-rings for hydraulic service assure low-friction, leakfree sealing at all operating pressures. Cylinders are offered in a wide range of bore sizes, with stroke lengths to suit requirements, and choice of six mounting types. Units are rated at 200 psi air and 500 psi hydraulic. Valvair Corp., 454 Morgan Ave., Akron 11, Ohio. F

Circle 662 on Page 19

Socket Screws

are flat-head units in miniature sizes

Designated Dyna-Mite, miniature flat-head screws are available in



No other valve design can handle a wider range of liquids and gases than... jamesbury

WATER
CHEMICALS
PETROLEUM
SEMI-SOLIDS
HIGH VACUUM
DRY POWDER
COMPRESSED GASES
ABRASIVES
SOLVENTS
SLURRIES
ALKALIES
ACIDS
AIR

"Double-Seal" Ball Valves

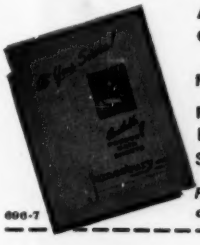
Valve Materials

Stainless	½" through 8" flanged
Aluminum	150 and 300 flanged series
Bronze	¼" through 3" screwed ends
Steel	¼" through 2" 3000 lb. valves
Other materials on application	(larger sizes on application)

P.V.C. ½" through 4" flanged
½" through 3" screwed

"Teflon" or synthetic rubber seals

Available with pneumatic and electric operators



Franchised Distributors In All Key Cities

Purchasing Agents — Complete Jamesbury "Double-Seal" Ball Valve Literature Should Be In Your Files. Ask for it!

Fill out coupon for Jamesbury literature or distributor service.

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Name _____ Title _____

Company _____

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☐ Jamesbury Literature ☐ Distributor Service

JAMESBURY CORP., 110 NEW STREET, WORCESTER, MASS.

Circle 504 on Page 19

Eliminate "high-cost specials" by standardizing on

AMERICAN STOCK GEARS

Investigate and you'll probably find that instead of having to go to the added time and expense of ordering special gears, that your needs can be filled from the American line.

American is a 'complete' stock gear line. Manufactured by Perfection – a veteran of over 30 years in the gear business – these gears are made to the most precise standards, from the highest quality materials. This popular line includes brass, bronze, steel, semi-steel, cast iron, and non-metallic gears in a range of 48 to 3 diametral pitch.

You'll save time and money . . . save on inventory . . . simplify purchasing and have less lost production time by procuring your stock gear needs from your nearby distributor of American Stock Gears.

Ask for FREE copy of American Stock Gear Catalog No. 360 containing detailed information and engineering data.

AMERICAN STOCK GEAR division

Perfection Gear Co., Harvey, Illinois

Circle 505 on Page 19

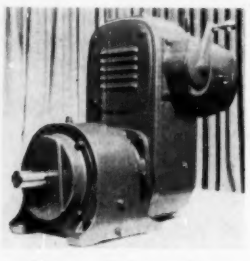
alloy or stainless steel with either hex or spline sockets. They are furnished in No. 0 through No. 3 sizes from stock. **Bristol Co.**, Waterbury 20, Conn. B

Circle 663 on Page 19

Adjustable-Speed Drives

in ¼ through 25-hp models

Mechanical adjustable-speed drives, designated Polydyne, are available in a wide range of outputs and speed ratios, and operate on principle of V-belt-connected, adjustable-



pitch pulleys. Belt replacement is enhanced by a design which assures adequate internal clearances. Controls are undisturbed, and belt tensioning is automatic and immediate. Actuating force is directed through an equalizer which prevents any binding or sticking of speed-control function. Control location is flexible and capable of quick relocation in the field to meet requirements. Drives are offered from ¼ through 25 hp, ac, in output speeds from 5 to over 4000 rpm, with standard speed variations of 2, 3, 4, and 5:1. Accessories include remote mechanical, remote electric, and pneumatic actuated controls. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 664 on Page 19

Limit Switch

in six gear ratios from 40:1 to 1080:1

Precision rotating-shaft limit switch, rated at 600 v maximum, can be used as a pilot device for controlling ac or dc reversing starters or contactors that operate motors on machine tools, cranes, hoists, mechanical presses, conveyors, valves, and other forward-reverse operations. Unit is available in six gear ratios from 40:1 to 1080:1. When mechanically coupled to driving equip-

New!

20 pages of helpful information about J-M Chempac Teflon products . . .

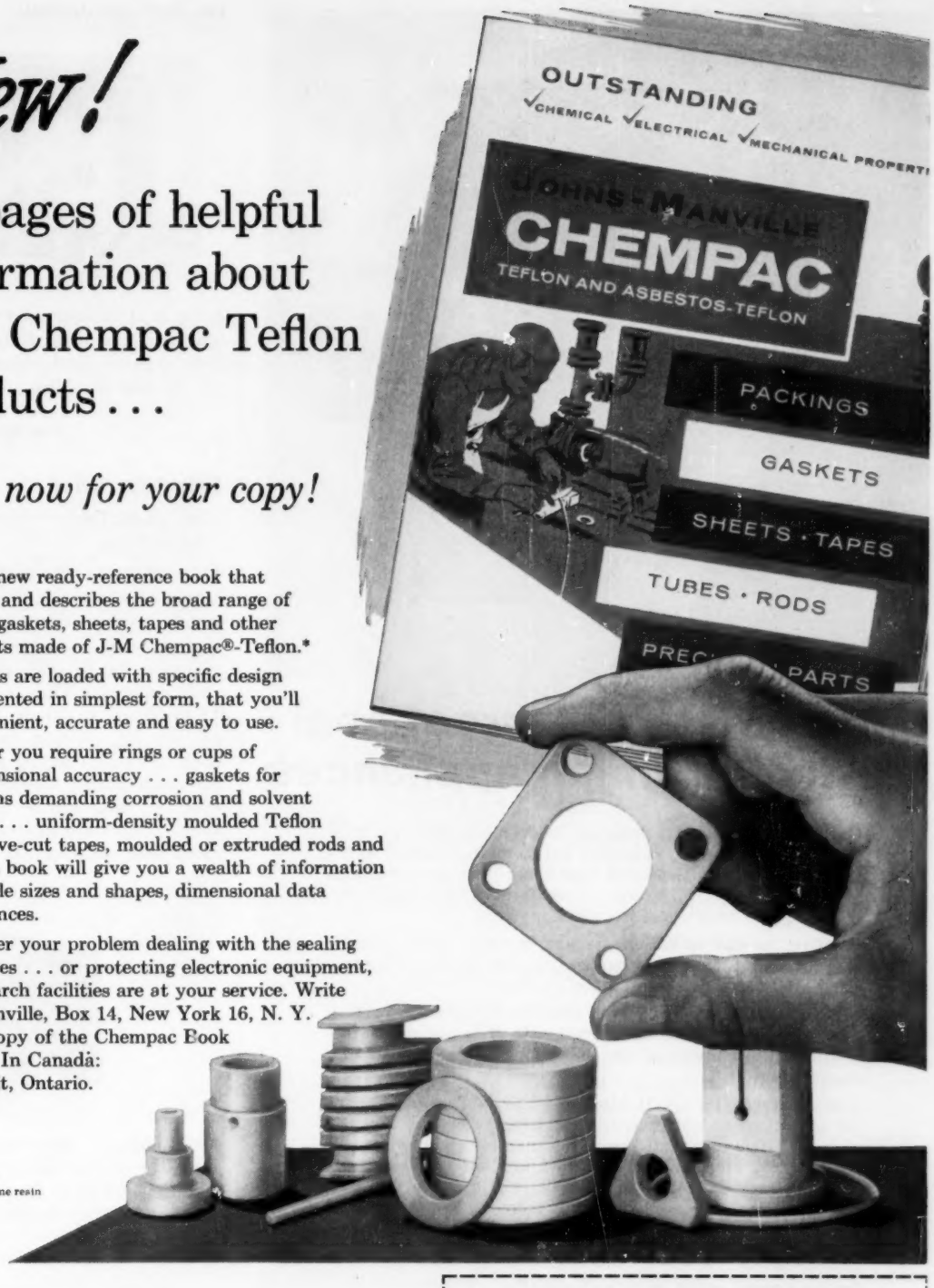
Send now for your copy!

Here's a new ready-reference book that illustrates and describes the broad range of packings, gaskets, sheets, tapes and other components made of J-M Chempac®-Teflon.*

Its pages are loaded with specific design data, presented in simplest form, that you'll find convenient, accurate and easy to use.

Whether you require rings or cups of high dimensional accuracy . . . gaskets for applications demanding corrosion and solvent resistance . . . uniform-density moulded Teflon sheets, skive-cut tapes, moulded or extruded rods and tubes, this book will give you a wealth of information on available sizes and shapes, dimensional data and tolerances.

Whatever your problem dealing with the sealing of corrosives . . . or protecting electronic equipment, J-M Research facilities are at your service. Write Johns-Manville, Box 14, New York 16, N. Y. for your copy of the Chempac Book PK-124A. In Canada: Port Credit, Ontario.



*TM for DuPont Tetrafluorethylene resin

JOHNS-MANVILLE

Johns-Manville, Box 14, New York 16, N. Y.

Please send me a free copy of the new Chempac-Teflon Brochure, PK-124A.

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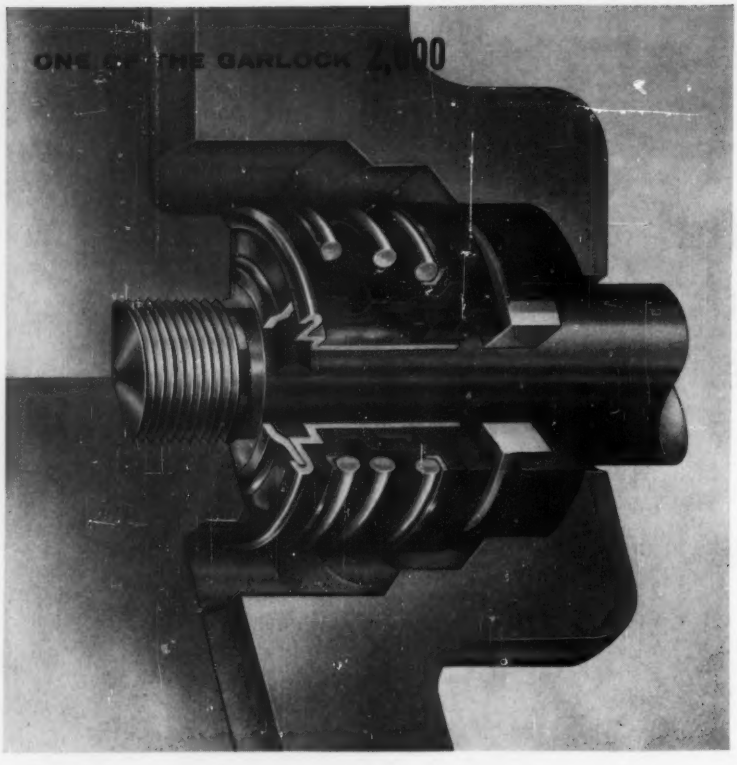

Low-cost, leak-proof seal for pumps, major appliances

Garlock H Mechanical Seals are widely specified for home water and oil pumps, reduction units, mass-produced appliances like washing machines, and other consumer products. Use them on ⅝", ¾", and 1" shafts and retain same top advantages of more expensive seals.

Positive, no-leak operation. Sealing surface of the ceramic stationary seat and the carbon sealing ring are lapped for precision contact—this assures a perfect seal.

Simple installation. You merely slide the self-contained rotary unit onto the lubricated shaft. Then, with oil or water, lubricate the outside diameter of the vibration ring and push into counterbore.

You can apply Garlock H Mechanical Seals wherever operating conditions do not exceed 212°F temperature, 75 psi pressure, and 1000 fpm shaft speed. For more severe applications, consider PK Mechanical Seals. Both are part of the Garlock 2,000 . . . two thousand different types of gaskets, packings, and seals for every need. Find out more by contacting your local Garlock representative, or write for Catalog AD-161.

THE GARLOCK PACKING COMPANY, Palmyra, New York

For prompt service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

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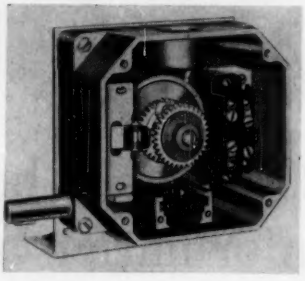
Canadian Div.—The Garlock Packing Co. of Canada Ltd. • Plastics Div.—United States Gasket Co.

Circle 507 on Page 19



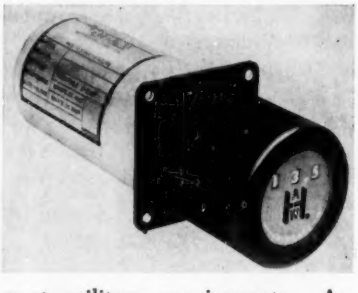
ment, it eliminates need for two to four remotely located conventional limit switches. **Cutler-Hammer Inc.**, 315 N. 12th St., Milwaukee 1, Wis. K

Circle 665 on Page 19

Time-Delay Relay

has delays from 0.1 to 30 sec

Time-delay relay for military applications is enclosed in a 2¼-in. round housing extending less than 4½ in. behind convenient panel-mounting flange, with only setting knob exposed. Time delays from 0.1 to 30 sec, in 0.1-sec increments, are set by rotating full-diameter knob containing setting and switching mechanism. Setting is clearly read on three digits in front of knob. Digits are internally illuminated with white or red lighting to



meet military requirements. Accuracy of ±1 per cent is maintained over range of 24 to 29 v dc. **A. W. Haydon Co.**, 232 N. Elm St., Waterbury 20, Conn. B

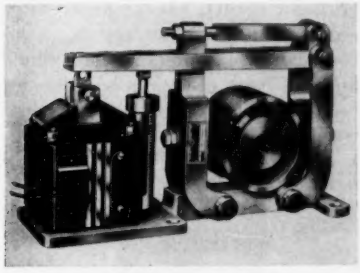
Circle 666 on Page 19

Shoe Brakes

are solenoid-operated

Theta shoe brakes can be converted from spring-set, magnetic-release to magnetically set, spring-release in less than 5 min. The solenoid-operated units range from TS-114, a 3 lb-ft, continuous-duty brake with

2.5-in. diam wheel and 1.5-in. face, to TS-142, a 1200 lb-ft, continuous-duty unit with 12-in. wheel diam and 6-in. face. Brakes are operated by relatively long-stroke solenoids, and are built so that only a part of stroke is used for releasing or setting brake. Other portion of stroke is used as a reserve to provide for wear of linings. Brake shoes are set on a spherical socket, permitting rotating movement of 15 deg in all directions. Spring characteristics are very flat, permitting large lining wear without alteration in torque setting. Brakes are available for ac for all voltages



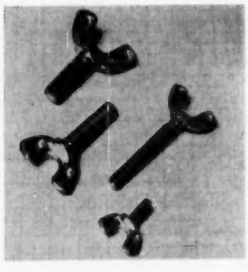
to 750 v and for all frequencies from 16 2/3 to 67 2/3 cycles. For dc shunt connections, they are available for voltages up to 750, and for series connections they are available for any value of current and to withstand 750 v to ground. **Trombetta Solenoid Corp.**, 329 N. Milwaukee St., Milwaukee 2, Wis. K

Circle 667 on Page 19

Wing Screws

are die cast from zinc alloy

Wing screws for a wide range of assembly applications are available in thread sizes from No. 6 through ½ in., wing spreads of 27/32 to 1⅞ in., and screw lengths from ¼ to 1¾ in. Die cast from zinc alloy, fasteners are furnished in one and two-piece assemblies. Screws have



FOR BIG POWER use Maxi-Power

PARALLEL SHAFT HELICAL GEAR DRIVES

1. Heavy duty, reinforced design housing for permanent alignment, rigid shaft support.
2. One mesh per reduction—fewer moving parts.
3. Broad faced helical gearing—high quality, accurately hobbed for greater strength, durability. Uniform tooth deflection under load . . . no uneven wear.
4. Shafts firmly held in place. Positive gear location assures full tooth engagement across entire face.
5. Smooth, overlapping mesh, close backlash tolerances, no oil trap, provide quiet operation, less heat generation.
6. Heavy duty, anti-friction bearings. Conservatively rated for wide range of operation.

Capacities to 1550 H.P.

★ Single, Double, Triple Reductions
★ Standard Ratios from 2.08 to 1 up to 360 to 1
★ 9 Shaft Arrangements
★ Available With Fabricated Steel Housing

There's more capacity, greater stamina and longer service life built into Foote Bros. Maxi-Power Parallel Shaft Drives. Simple, balanced design, fewer moving parts, heavy duty construction, efficient lubrication and conservative ratings make Maxi-Power drives the logical choice for critical applications and severest operating conditions.

You can depend on Maxi-Power Drives to produce maximum performance with minimum attention because they're built for just that kind of service.

Write for Engineering Manual MPB . . . has complete details and data. There's no obligation!

100 YEARS SERVING INDUSTRY 1859-1959

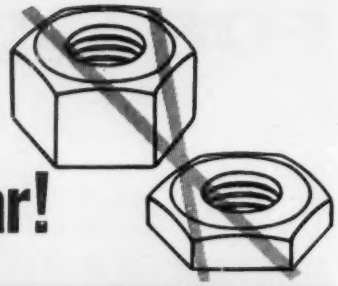
FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS

Circle 508 on Page 19

Save 65¢ on each Fastener Dollar!

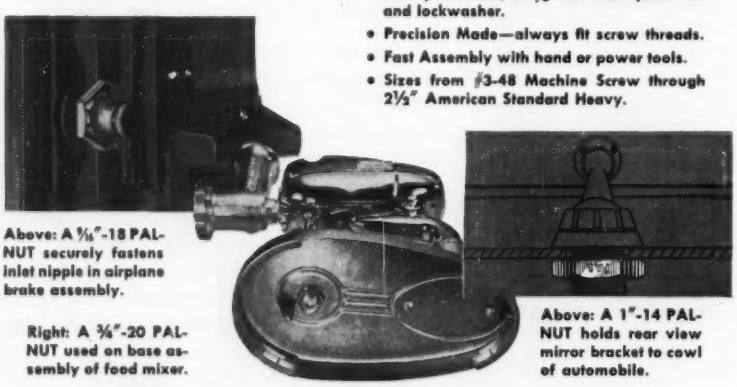


Replace expensive heavy nuts and jam nuts with low-cost, vibration-proof

PALNUT TYPE R LOCK NUTS

All PALNUT Lock Nuts provide attractive savings—but in sizes from ⅜" and up, the ratio of economy increases dramatically. On many applications, Type R PALNUT Lock Nuts can do the job better, at ⅓ the price! PALNUT spring-tempered steel lock nuts provide rugged assembly for loads in shear and moderate tensile loads, in sizes up to 2½" diameter. In addition, you get the following design and cost advantages:

- Vibration-proof assemblies without lockwashers.
- Save Space—need only 3 bolt threads, permit shorter bolts.
- Save Weight—PALNUTS weigh 65% less than plain nuts, 80% less than plain nut and lockwasher.
- Precision Made—always fit screw threads.
- Fast Assembly with hand or power tools.
- Sizes from #3-48 Machine Screw through 2½" American Standard Heavy.



Above: A 5/16"-18 PALNUT securely fastens inlet nipple in airplane brake assembly.

Right: A ¾"-20 PALNUT used on base assembly of food mixer.

Above: A 1"-14 PALNUT holds rear view mirror bracket to cowl of automobile.

Write for literature and free samples, stating type, size and application.

THE PALNUT COMPANY, 75 Glen Road, Mountainside, N. J.

In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS

Quick, secure fastening at low cost

smooth-acting, washer-like bosses which promote firm seating. They have excellent corrosion resistance for most applications. Nonstandard thread sizes and lengths, as well as special points, can be specified for both one and two-piece units. **Gries Reproducer Corp.**, 125 Beechwood Ave., New Rochelle, N. Y. D

Circle 668 on Page 19

Electronic Counter

has speeds to 3000 counts per min

Electronic counter is completely transistorized and equipped with printed circuitry. It functions with accuracy at speeds up to 3000 counts per minute and has minimum of heat radiation, so that no ventilation is required. Equipped with a separate, optional photohead,

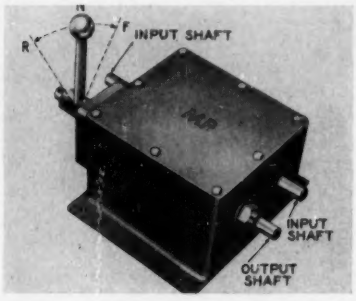
unit operates from a 105-125-v circuit. It can also be supplied for operation on 220 v ac. Counter, designated Model D, is equipped with pushbutton reset and is designed for rugged industrial use. **Veeder-Root Inc.**, Hartford 2, Conn. B

Circle 669 on Page 19

Reversing Transmission

for light to medium-power use

Instant - Reverse transmission is available in a variety of models for service in machine tools, small automotive units, farm, garden, and lawn power implements, mobile, portable, and stationary materials-handling equipment, marine power, construction, and maintenance machinery. Transmission, combining direct-gear and chain-drive principles with two opposing clutches, features fast action, smooth reversing at all speeds by single-action



lever. Forward and backward movements of lever engage clutches alternately with forward or reverse drives. Directional changes are smooth and entirely clutch-action, and can be instantaneously at any speed. **Transmission Div., Mentor Products Inc.**, Mentor, Ohio. F

Circle 670 on Page 19

Silicon Power Rectifiers

miniature units have 6 or 35-amp ratings

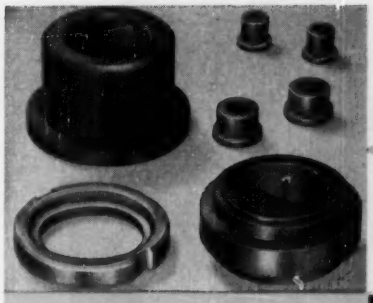
Two lines of miniature stud-mounted silicon power rectifiers combine high power-handling ability with minimum of size and weight. Rectifiers, designed for continuous operation at current ratings of 6 and 35 amp at 150 C case temperature, are available in 7/16 and 11/16-in. hex base configurations, respectively. Peak inverse ratings for both series range from 50 to 600 v. **Transitron Electronic Corp.**, 168 Albion St., Wakefield, Mass. B

Circle 671 on Page 19

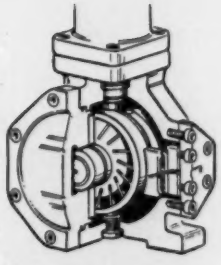
Plastic Fan

for use at speeds to 11,000 rpm

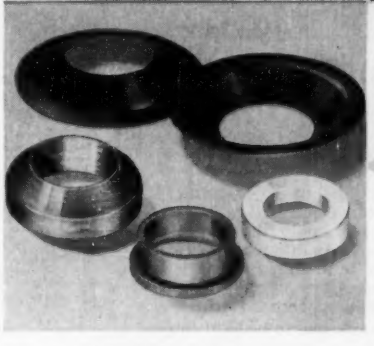
Four-bladed propeller fan of acrylonitrile copolymer plastic is for high-

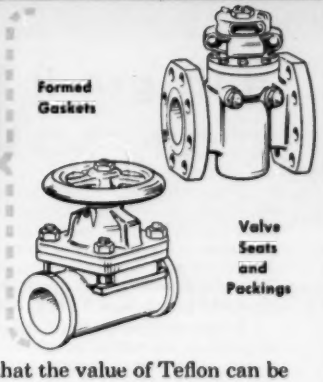


FOR: Guide Bushings, Vanes and Wear Rings



HAVE YOU CONSIDERED THE IMPORTANT ADVANTAGES OF FILLED TEFLON*?





It has been definitely established that the value of Teflon can be considerably enhanced by the use of fillers in certain applications. Laboratory and field experience has demonstrated that the use of fillers permit Teflon to be more readily tailored to a wide variety of chemical, electrical and mechanical applications. Also, some mechanical properties can be improved. These include:

1) resistance to deformation under load
2) resistance to wear
3) thermal conductivity
4) compressive strength
5) hardness

By thus improving its properties, Teflon now offers even greater industrial potential. This is the reason filled Teflon has become an important item in the "John Crane" Chemlon® line of better Teflon products.

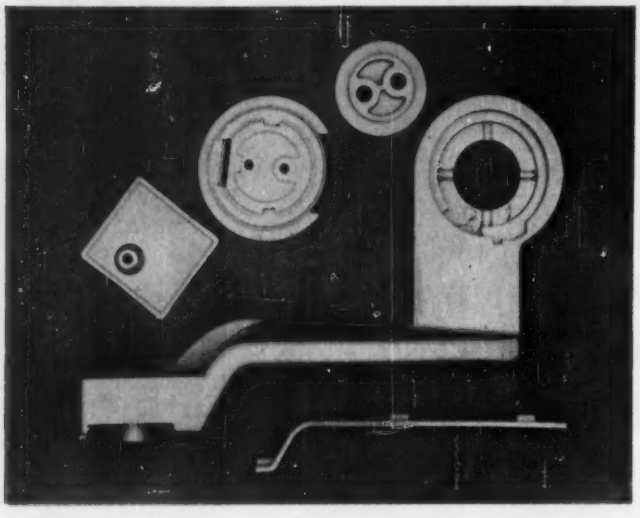
Chemlon is available with such fillers as glass fiber, carbon, graphite, copper and bronze, talc, calcium fluoride and other inorganic materials.

Tell us about your requirements. We'll tell you the advantages you can get from filled Chemlon. Request Bulletin T-104.

Crane Packing Company, 6425 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont

*DuPont Trademark

POLAROID specified dimensional accuracy

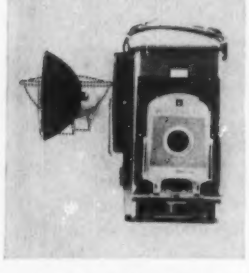


and got it from CONSOLIDATED

Both dimensional accuracy and fine appearance were essential requirements in the production of this camera flash attachment for Polaroid. Naturally, mold planning and construction were of utmost importance in such a critical job. Precision and timing had to be built into the mold design. Three different molds were necessary to produce the five separate pieces which form one synchronized unit.

In assembling the unit, all parts had to be kept in perfect alignment; no warpage or twist was permitted. For appearance's sake, it was necessary to locate mold parting lines on the natural edges of the pieces.

This flash attachment unit represents the type of molding challenge Consolidated welcomes. We appreciate the opportunity to quote on any molding – complicated or simple.



The Polaroid Bounce Flash Bracket (Model #292), with swivel-type flash gun clip, permits the taking of both horizontal and vertical pictures without removing the gun to change its position.

For more than 80 years we have been filling exacting plastics orders for the nation's blue chip companies. Before you discard any design you feel can't be molded in a plastic, call Consolidated.

CMP

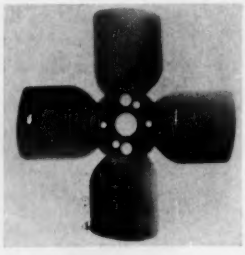
"Your Blueprint in Plastics" Since 1874

CONSOLIDATED MOLDED PRODUCTS CORPORATION

335 Cherry St., Scranton 2, Penna.

Send for your free copy of our new 20-page Facilities Report.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



volume production of air-moving devices such as portable appliances and electronic cabinet cooling units. Series GU fan, with 4-in. diam, is available for use at speeds to 11,000 rpm. It rotates clockwise, and is designed for a unit bearing mount. **Air Impeller Div., Torrington Mfg. Co.**, Torrington, Conn. B

Circle 672 on Page 19

Anti-Galling Lubricant

has zinc base and plastic consistency

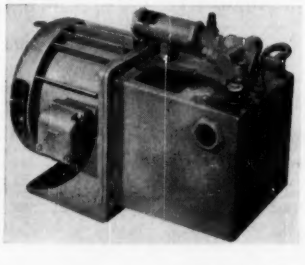
No-Gall lubricant prevents galling and corrosion of tapped threads in construction, mining, quarrying, and oil-field drilling equipment, and serves as an effective anti-friction, anti-seize compound for metalworking, industrial, and marine applications. It serves as a superior drawing and forming compound, provides an effective moisture-resistant gasket seal, and eliminates seizing and galling in high-pressure applications. A zinc-base lubricant, it is made in plastic consistency for brush or paddle application, and does not dry out or harden. **Keystone Lubricating Co.**, 3100 N. 21st St., Philadelphia 32, Pa. E

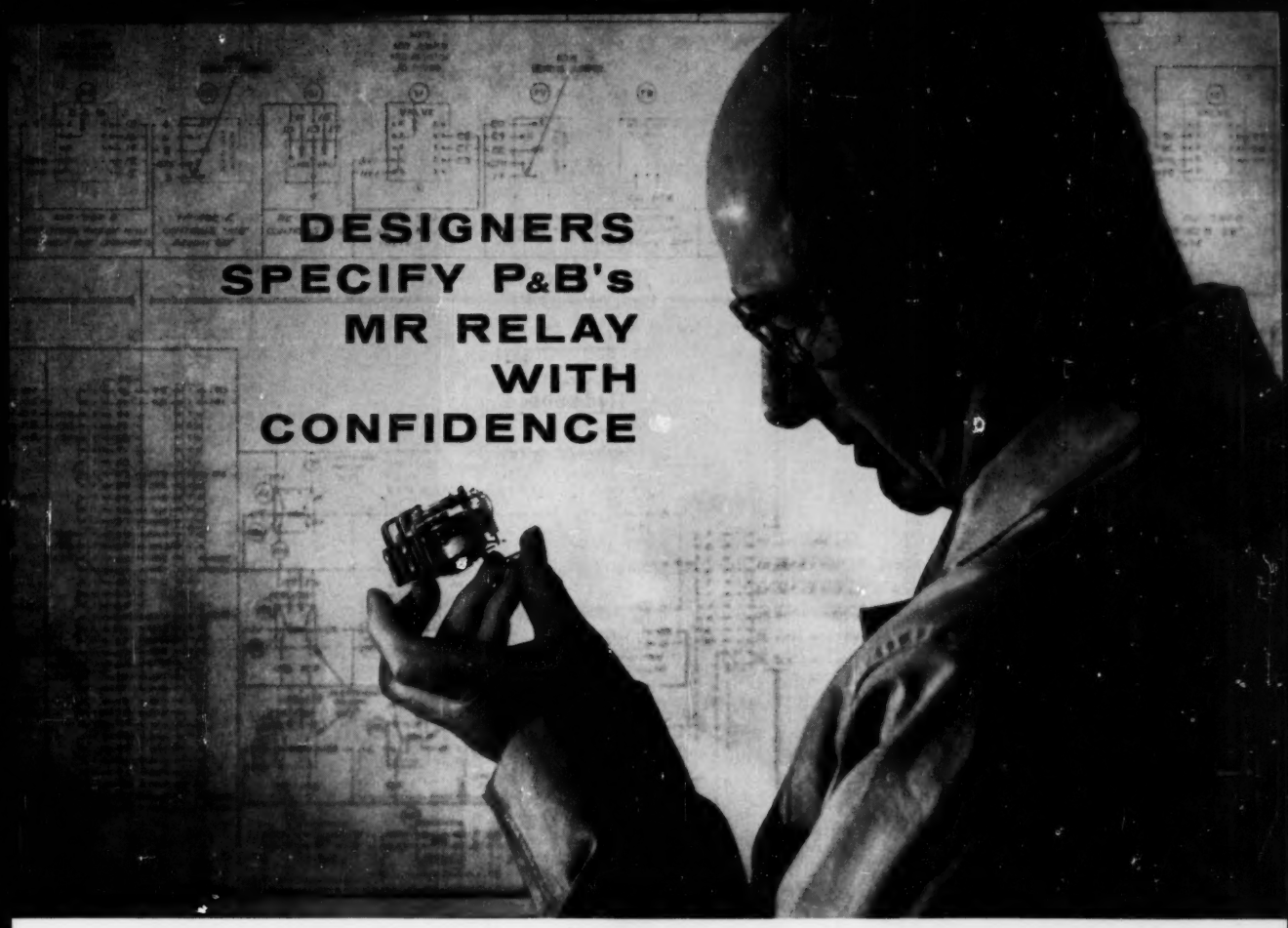
Circle 673 on Page 19

Hydraulic Power Unit

provides high performance in small package

Compact wafer-type motors are used in new hydraulic power unit to





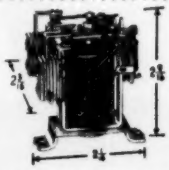
for a host of control applications

RELIABILITY coupled with low cost are two factors which place the MR series relays high on P&B's best seller list. They are being used in a multiplicity of designs . . . transmitters, street lighting equipment and small motor starters, to name but a few.

Both AC and DC models are available, with AC coils ranging up to 440 volts. All are adaptable for printed circuit mounting. The wide variety of contact arrangements include:

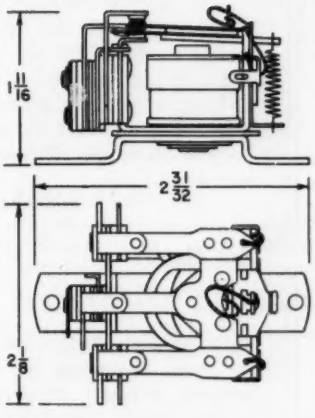
SPST-NO	SPST-NC-DB	DPST-NC	3PST-NC
SPST-NC	SPDT	DPDT	3PDT
SPST-NO-DB	DPST-NO	3PST-NO	

For more information about this medium duty, compact relay, call or write today—or get in touch with the P&B sales engineer nearest you. See our complete catalog in Sweet's Product Design File.



LM SERIES: Plate circuit relays similar to the MR. All sp and dp contact arrangements shown above are available. Coils are wound to specified resistances up to 58,000 ohms max. Sensitivity ranges from 15 mw min. (single pole) to 70 mw min. (double pole).

MR SERIES



GENERAL SPECIFICATIONS:

Breakdown: 1500 volts, 60 cycle rms between all elements.

Temperature Range:
DC —55°C. to +85°C.
AC —55°C. to +75°C.

Pull-in: Approx. 75% of nominal dc voltage; 78% of nominal ac voltage.

Weight: 4 ozs.

Dimensions: 2 31/32" long x 2 3/4" wide x 2" high.

Mounting: Two 9/32" dia. holes. Can be adapted for printed circuits.

CONTACTS:

Arrangements: Up to 3pdt.

Material: 7/32" dia. silver. (Others available).

Load: 8 amps @115 volts, 60 cycle, resistive.

COIL:

Max. Resistance: 34,500 ohms.

Power: 1.5 watts dc; 3.25 volt-amps ac. Will withstand up to 6 watts at 25°C.

Voltages: Up to 110 volts dc; up to 440 volts 60 cycle ac.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

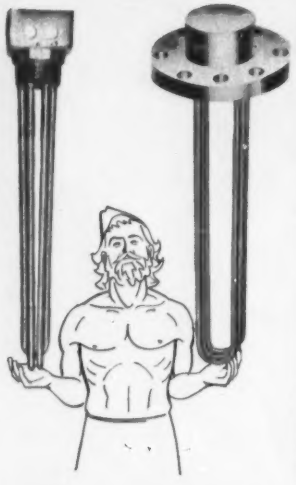
POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

IN CANADA: POTTER & BRUMFIELD CANADA, LTD., GUELPH, ONTARIO

Circle 511 on Page 19

Flange or Threaded Bushings for



VULCAN

IMMERSION HEATERS

Vulcan Electric Tubular Immersion Heaters offer a choice of flange or threaded bushings; bayonet type, side or bottom outlet; copper, steel, stainless or alloy sheath; single or three phase; 500 to 10,000 watts (or higher); 120, 240, 480 volts (or higher); pressures up to 3500 psi.

Vulcan Immersion Heaters are ideal for heat transfer to all types of liquids — water, oil, wax, paraffin, asphalt, tars, etc.; in tanks, boilers, urns, kettles and other containers.

Send coupon for complete information.

VULCAN ELECTRIC COMPANY Danvers, Mass.

Cartridges • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

VULCAN ELECTRIC COMPANY, Danvers 6, Mass.

Please send catalog and prices on Vulcan Immersion Heaters.

Name & Title.....

Company.....

Street & No.....

City & State.....

Circle 512 on Page 19

drive pumps of ½ to 30-gpm capacity at pressures to 2500 psi. Available in both ac and dc models with all types of attachments, unit provides high performance in a small package. Unit shown has external line filter and adjustable relief valve. Construction with pump under reservoir oil gives quiet operation. **Spencer Hydraulics Inc.**, 2048 Clark St., Racine, Wis. K

Circle 674 on Page 19

Self-Tapping Screw

for use in sheet metal, plastic, and wood

Self-Drill, Self-Tap screw is designed for power driving, and is suited for both manual and automated assembly operations. Designed for use in sheet metal, plastic, and wood, it can also be preassembled with various types of

plain, special, and lock washers and sealing washers to meet requirements for specific applications. Limited range of sizes is presently available. **Reliance Div., Eaton Mfg. Co,.** S. Erie and Charles Streets, Massillon, Ohio. G

Circle 675 on Page 19

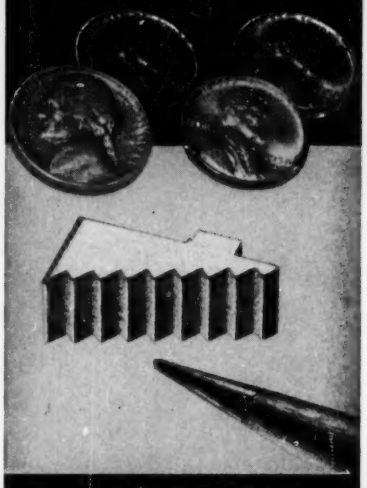
Fan Motors

in 1 to 125-hp ratings

Air-Over fan motors are designed for quiet operation in ventilating systems, exhaust systems, cooling towers, and all air-moving installations where a motor drives a propeller or axial-flow fan. Design makes use of air circulated in the installations to cool motor so that maximum horsepower is produced from minimum rotor size. Individual motor nameplates indicate three horsepower ratings (nominal, operating, and maximum) that can

Only 8 Cents

. . . for this intricate Minicast part . . .



in quantities of 100,000

Here is another dramatic example of the benefits to be gained from the new Minicast precision process. In addition to an unusually low per unit cost for the part, strict specifications had to be met.

For example, the Minicast process had to provide

- an average maximum radius of .003 on the teeth
- specific tolerances of plus or minus .001
- no tolerance greater than plus or minus .003
- and produce the parts in non-machinable stellite

If you use intricate parts in similar quantity ranges, chances are the Minicast process is your answer to lower costs.

Get the complete story . . . Write for this new descriptive brochure . . . it's free of course

CONSOLIDATED FOUNDRIES AND MFG. CORP.

Casting Engineers DIV.

2321 NORTH BOSWORTH AVENUE CHICAGO 14, ILLINOIS

Circle 513 on Page 19

GITS ECONOMY SEALS

FOR HIGH-VOLUME COMMERCIAL USE

Economy is usually a primary consideration in high-volume commercial sealing applications. The Gits Commercial Seal Division specializes in design and manufacture of these and other seals for just such applications — with this economy requirement in mind.

MARK VI

For all types of water pumps. Useful in high-volume appliance and domestic water pump sealing applications. Rugged, durable, efficient. Specified where performance must be combined with economy.

STYLE SGU

A factory-assembled unit-type seal for household appliance manufacturers and other small-budget users — Disposal Machines, Washing Machines, Refrigerators.

Plus

these and other seals for standard

INDUSTRIAL APPLICATIONS

UNIT SEAL

A complete packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Used on Speed Reducers, Gear Motors and many other types of Power Transmission Equipment and Machine Tools.

STYLE DPC

An extra-rugged carbon- or bronze-faced seal, for more compact installation in heavy machine tools and other industrial machinery.

Write for detailed data

GITS BROS. MFG. CO.

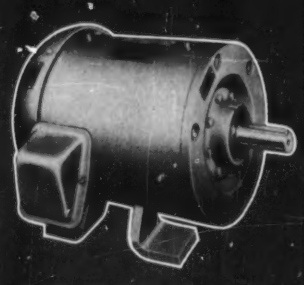
COMMERCIAL AND INDUSTRIAL SEAL DIVISION

1868A South Kilbourn Avenue • Chicago 23, Illinois

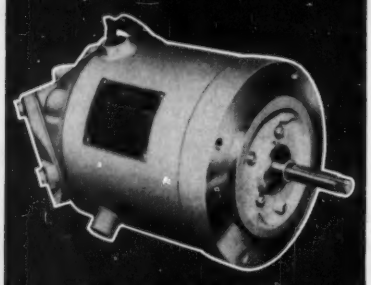
Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century

Circle 514 on Page 19

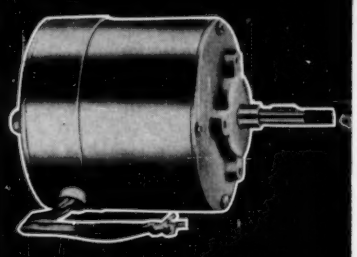
Military Motors



SPRAY-TIGHT, FAN COOLED,
HI-SHOCK
MIL-M-17060A



SPRAY-TIGHT, HI-SHOCK
MIL-M-17413



SPRAY-TIGHT, HI-SHOCK
MIL-17059

These Peerless motors meet all critical military codes. Spray-Tight Service "A" units withstand tremendous shock, high vibration levels and great temperature changes.

The Peerless military motor is available in drip-proof, splash-proof, totally enclosed, spray-tight and water-tight construction from ½ to 30 HP.

All motors meet specifications of ABS, U. S. Coast Guard, MIL-M-17413 (DC), MIL-M-17060A and 17059 (AC), AIEE 45 and radio interference. With standard or special mountings and features, they serve at land-based radar installations and aboard vessels throughout the world.

Give us your military motor problem. We'll work with your engineers to produce the motor which serves your needs best and meets the particular military specifications involved.

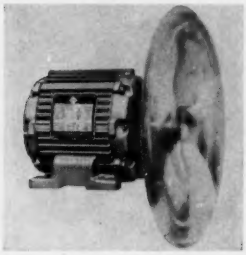
ELECTRIC MOTOR DIVISION

THE *Peerless Electric*® COMPANY

FANS • BLOWERS • MOTORS

1520 W. MARKET ST. • WARREN, OHIO

Circle 515 on Page 19



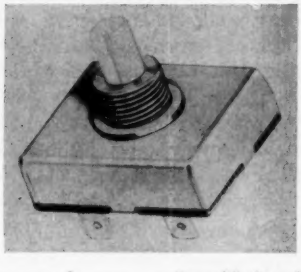
be achieved by varying air velocity across motor. Motors, with ratings from 1 to 125 hp, are available with foot or flange mountings in totally enclosed and explosionproof enclosures. They are suitable for vertical or horizontal mounting. **Louis Allis Co.**, Dept. P, 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 676 on Page 19

Rotary Switch

is available in eight switch positions

Designed for appliance, vending machine, and other industrial applications, Series 777 rotary switch is available with eight different combinations of 1, 2, or 3 SPST switch positions. Unit features 3/16-in. wide spade terminals with holes for solder connections, positive index-



ing, metal cover, and molded nylon shaft and cam. It is rated at 10 amp, 125 v ac; ⅓ hp, 125/250 v ac. **Controls Co. of America**, 9555 Soreng Ave., Schiller Park, Ill. J

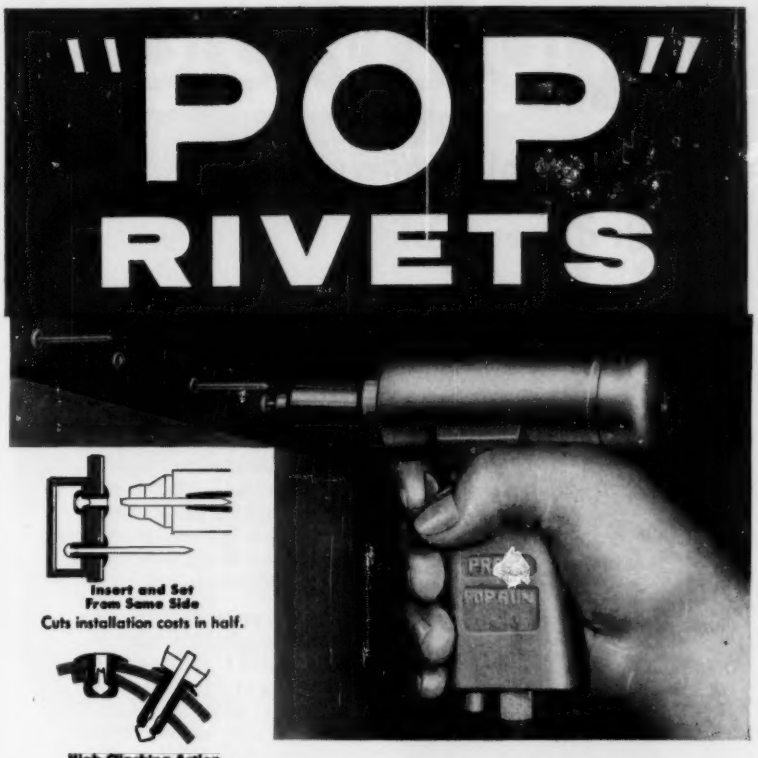
Circle 677 on Page 19

Computer-Grade Capacitors

have high mfd values

Alumalytic computer-grade capacitors are available in new case size. 3 in. diam by 5⅝ in. high. Microfarad values at all voltage ratings are from 23 to 275 per cent higher than previously available. Three-volt unit in new case size (shown) has capacitance of 150,000 mfd.

"POP" RIVETS



Insert and Set From Same Side
Cuts installation costs in half.

High Clinching Action
Pulls parts together with up to 600 lbs. squeeze. Eliminates need to clamp.

Wide Grip Range
Simplifies inventory, purchasing, inspection. Same length "POP" Rivet holds tight through thick or thin.

Vibration Proof
"POP" Rivets cannot back out or become loose. Ensures tight assembly for years of use.

Low Head Profile
Where space is important, "POP" Rivets' minimum head height eliminates clearance problems and improves appearance.

Least Back-Up Space
Strong, high strength "POP" Rivets need only enough back-up space to provide room for set head. Gives more compact design.

- *Cut Assembly Costs*
- *Solve Design Problems*
- *Installed and set from same side*

"POP"® Rivets cut *installed fastener costs*, add design flexibility, and increase assembly convenience because they are inserted and set from the same side. Up to 1200 can be set per hour right on the assembly line — even by an unskilled operator.

"POP" Rivets are precision made, hollow rivets assembled on a solid high tensile mandrel. The setting tool pulls the mandrel head into the rivet from the front side, setting the rivet on the reverse side. Mandrel breaks under tension of up to 1600 lbs. and falls free.

You can cut installed costs, increase assembly convenience, and secure high speed, trouble-free fastening immediately with "POP" Rivets. No need for complicated or extensive re-tooling. Simplify product design, cut handling time. Call or write us today — now — and start cutting your *installed fastener costs* with "POP" Rivets! Or better still, send us a sample assembly for riveting.

"POP"

"POP" Rivet Division
UNITED SHOE MACHINERY CORPORATION
Shelton, Conn., Regent 5-3391

Circle 516 on Page 19

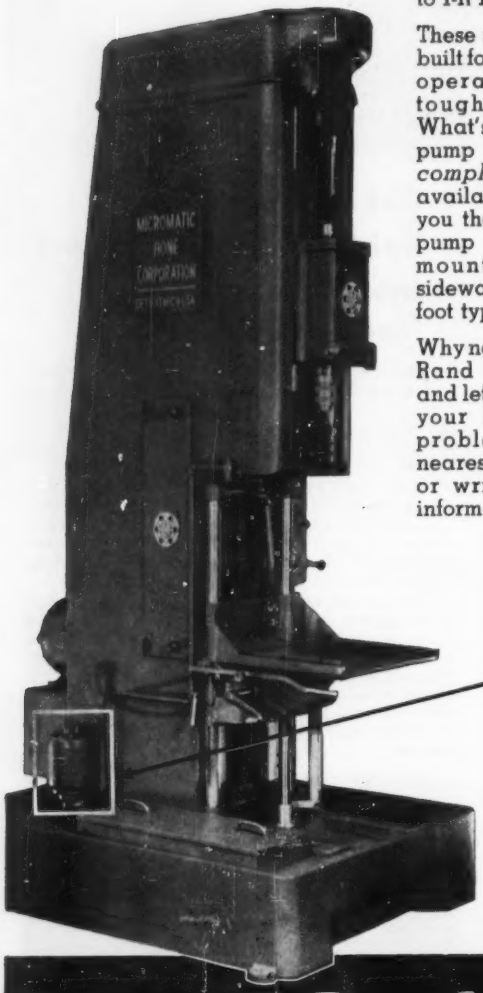
versatile

pumping power

with dependable

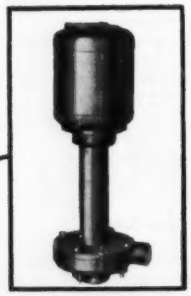
MOTOR PUMPS

The efficient handling of coolant, cutting oils and washing liquids in modern production equipment calls for maximum pumping efficiency. And to solve the various problems in all types of equipment, designers today look *first* to I-R Motorpumps.



These rugged pumps are built for long, trouble-free operation under the toughest conditions. What's more, the Motorpump line is the most *complete* line of pumps available today, offering you the widest choice of pump sizes, types and mountings including sidewall, immersion or foot type.

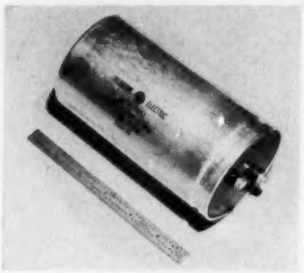
Why not call an Ingersoll-Rand pump specialist and let him help you with your liquid handling problems. Call your nearest I-R branch office or write for complete information.



An immersion type Motorpump handles abrasive coolant on a modern honing machine.

9-820

Ingersoll-Rand / 11 Broadway, New York 4, N. Y.



Many units in three smaller case sizes have capacitance ratings raised from 3 to 50 per cent. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 678 on Page 19

Timing and V-Belt

permits power transmission with no lubrication

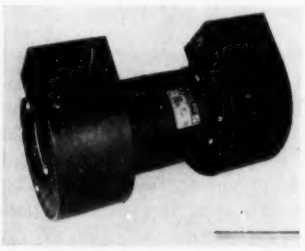
Combination timing and V-belt is an integral unit which permits transmission of power with both sides of the belt. V-belt side of dual belt is notched to make it more flexible. Designated T-V, belt is currently manufactured in standard $\frac{3}{8}$ and $\frac{1}{2}$-in. pitches for light and heavy-duty applications. Belt operates at speeds to 16,000 fpm, and can operate on fixed centers without take-up adjustments. It is extremely compact, and speed ratios to 30:1 are possible. Flexibility of timing belt permits pulley diameters as small as $\frac{1}{2}$ in. at 10,000 rpm, even with relatively heavy loads. **United States Rubber Co.**, 1230 Avenue of the Americas, New York 20, N. Y. C

Circle 679 on Page 19

Double Blower

has output at 3300 rpm of 100 cfm free air per blower

B3-32 double blower is powered by a 115-v ac, single-phase, 60-cycle motor. It has minimum output of 100 cfm free air per blower at 3300



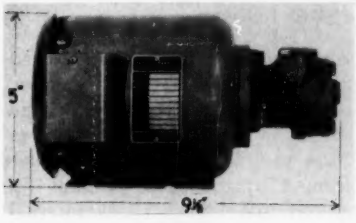
rpm. Unit, which has an exceptionally low noise level, has overall length of approximately 8 in. **Electro Products Div., Western Gear Corp.,** 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 680 on Page 19

Pump-Motor Combination

is small, lightweight unit

Developed for applications where space and weight are limited, Series 42 pump-motor measures 9⅛ x 5 in. It incorporates a totally enclosed electric motor rated for 1/12 to 1/6 hp, and an internal gear



pump with capacity of 1/3 to 3 gpm. Series consists of 24 models, all of which can be furnished with or without built-in relief valve. **Tuthill Pump Co.,** 953 E. 95th St., Chicago, Ill. J

Circle 681 on Page 19

Anchor Nuts

are 23 per cent lighter than previous units

Balanced design of Weight/Master anchor nuts is achieved by removal of excess metal without sacrifice in full performance. Nuts comply with all industrial-military specifications, and are 23 per cent lighter than previous units. Single-lug, two-lug, and corner types are furnished in five sizes from 4-40 to ¼-28. **Voi-Shan Mfg. Co.,** 8463 Higuera St., Culver City, Calif. L

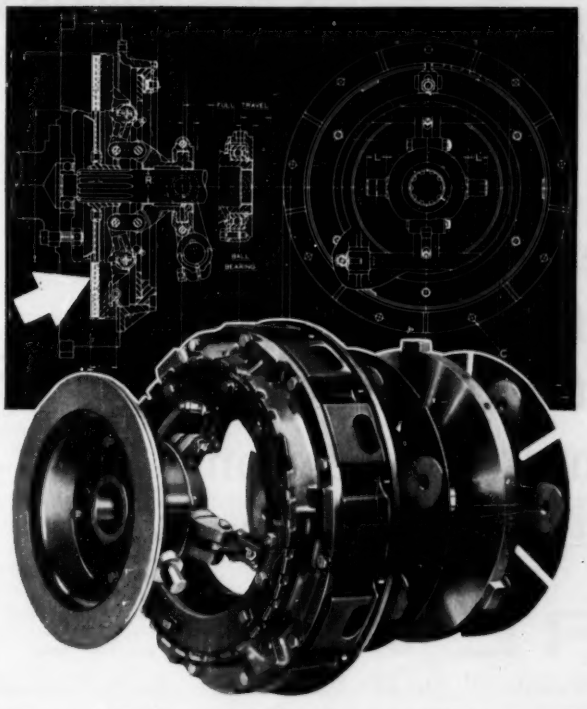
Circle 682 on Page 19

Floating-Dome Nut

miniature unit is stainless steel

M14730 miniature, two-lug, self-sealing, floating-dome nut is available in stainless steel for nonmagnetic applications. It is especially useful in units requiring hermetic sealing or when sealing against

ROCKFORD



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

Double Plate Clutch Provides More Torque - With Less Size

Used in a large crawler-type tractor, this Double-Plate ROCKFORD Morlife CLUTCH (Utilizing two MORLIFE® plates—equipped with button type facings) provides 100% more torque capacity than previous clutches of same diameter. 400% more service life and 50% more heat resistance are other features of this Heavy-Duty ROCKFORD Morlife CLUTCH. A brake plate is mounted on the heavy-duty, ball bearing type release sleeve.

If you have a heavy-duty vehicle in the planning stage, it will pay you to learn about these and other advantages of this new clutch—before you design the drive line. A design study of your present drive lines might indicate advantages of using this ROCKFORD CLUTCH. For information write Dept. D — or

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

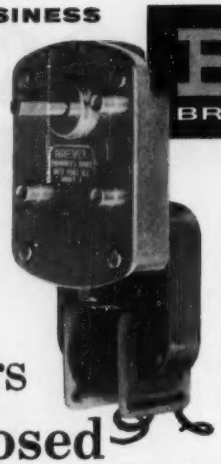
311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

SLOW MOTION IS OUR BUSINESS



BREVEL

NEW!

Brevel "F" motors have **fully-enclosed gear trains;** provide maximum protection of gears against dirt.

Designed to give maximum power transmission at lowest noise level by use of specially cut helical gears. Optional features—brake, clutch, and cooling fan—make it suitable for a wide variety of applications. Like all Brevel Motors, this new "F" Motor provides reliable power at low cost.

Write, wire, or phone today for Catalog 28R.

You will receive information on Brevel's complete line of small gear head motors.

BREVEL

Brevel Products Corp., 601 West 26th St., New York 1 • WAtkins 4-4737

Circle 519 on Page 19

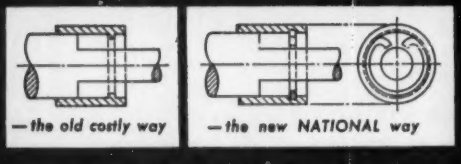
SAVE ON MATERIALS

NATIONAL RETAINING RINGS

—improve products and cut costs substantially!

SAVE ON LABOR

Efficient and economical NATIONAL Retaining Rings reduce weight, save space, simplify assembly and reduce production operations. Elimination of machining to form shoulders, threading, nuts and cotter pins are typical savings that can be effected. Ask NATIONAL for complete information and data on your particular applications, now!



—the old costly way

—the new NATIONAL way

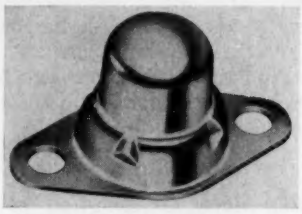
FREE SAMPLES

And descriptive literature will be sent promptly on request. Call or write to National, today.

The NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN



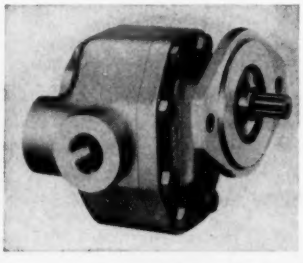
pressure differentials. Nut is available in 6-32, 8-32, and 10-32 thread sizes. **Nutt-Shel Co.**, 2701 S. Harbor Blvd., Santa Ana, Calif. L

Circle 683 on Page 19

Lightweight Pumps

have capacities from 4 to 150 gpm

Aluminum hydraulic pumps, available in either direction of rotation, operate at pressures to 2000 psi, speeds to 3000 rpm, and temperatures to 160 F. Capacities range from 4 to 150 gpm. Pumps run quietly and absorb shock internally. Design simplicity permits low



cost and ease of maintenance. **Hydraulic Products Div., Clark Equipment Co.**, Benton Harbor, Mich. H

Circle 684 on Page 19

Brake Motors

provide high torque and quick stops

Type FC brake motors are available for start-stop operations in drives and positioning systems. Featuring extremely high torque-to-size ratio, they can be wound for 115 or 200 v ac, 60 or 400 cycles in hysteresis-synchronous or induction types. Intermittent torques to 12 oz-in. are attainable. Electromechanical brake has epoxy potted coil wound for any desired voltage to 100 v dc; diode in circuit provides dc power. Brake holding force is 10 oz-in., and engagement time is 40 to 50 millisec. Depending on

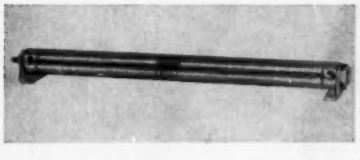
requirements, brake can be actuated either by energizing or de-energizing coil. Units are 1.675 in. in diam by 3.75 in. long, and weigh 17 oz. They are particularly useful for antibacklash stopping operation in automation equipment. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 685 on Page 19

Air Cylinders

throw-away units are available in larger sizes

Previously available in stroke lengths to 3 in., stainless-steel non-repair air cylinders are now available in double-acting stroke lengths up to 18 in. Bore cylinder of 1 1/16 in. exerts force of approximately 0.9 air-line pressure and operates at pressures to 150 psi. Body and piston rod are type 304 stainless steel, and piston contains two synthetic-rubber U-cups. Rolled-in



construction on front and rear head allows cylinders to be mounted in minimum of space. **Bimba Mfg. Co.**, 101 Main St., Monee, Ill. J

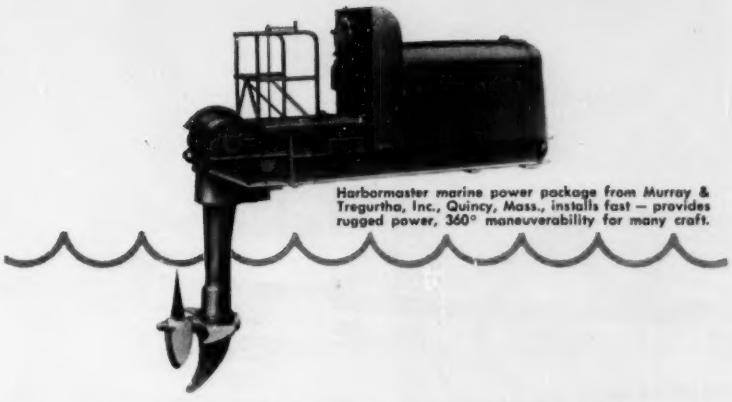
Circle 686 on Page 19

V-Band Coupling

has standard hex-head bolt for easy replacement

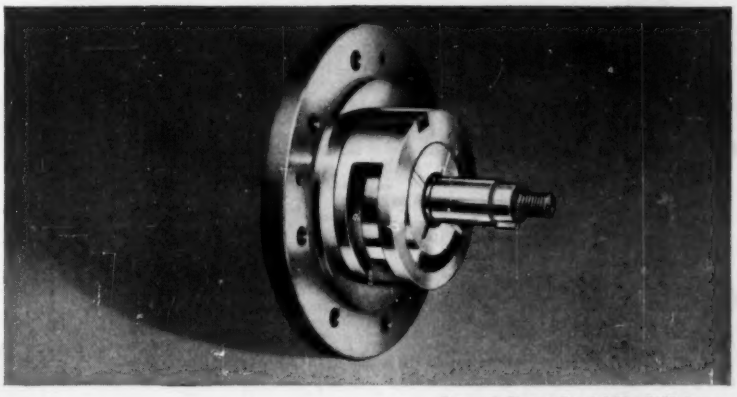
V-band coupling is available for joining ductwork, tubing, axial machine elements, and engine exhaust connections. New latch mechanism takes a standard, replaceable hex-head bolt. If nut and bolt freeze together under corrosive or extreme conditions, bolt is cut,

(*Please turn to Page* 188)



Harbormaster marine power package from Murray & Tregurtha, Inc., Quincy, Mass., installs fast — provides rugged power, 360° maneuverability for many craft.

Why "Harbormaster" designers choose Brown & Sharpe Pumps



Brown & Sharpe Special No. 8103 Pump

Problem: Designers of this heavy-duty marine power package want a dependable self-priming, positive displacement pump in the bottom of the outboard propulsion column to provide a fountain of lube oil to bearings and gears at the top of the column. The pump has to maintain unidirectional delivery, regardless of direction of shaft rotation (propeller in forward or reverse) — in any position (horizontal to vertical) — at variable speeds of 96 to 410 rpm. It must also be economical, and long-lasting.

Solution: Brown & Sharpe's Special No. 8103 Automatic Reversing Vane Pump, suggested by the local B&S engineer-representative, is now built into each Harbormaster. It uses ports provided in the casting.

Idea: For the best solution to any pump problem — Contact Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I. — or your B&S engineer-representative. Brown & Sharpe makes gear, vane and centrifugal pumps to handle more fluids than any other manufacturer.

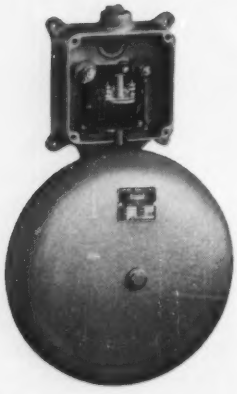
Brown & Sharpe
PRECISION CENTER

Circle 521 on Page 19

CABIN CRUISER:

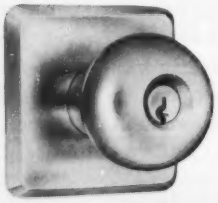
Railings and supports of Carpenter Stainless Tubing give maintenance-free styling to this power boat.

design with Carpenter



ALARM BELL:

Use of Carpenter Stainless Tubing gives the armature in this bell needed close tolerance without further machining.

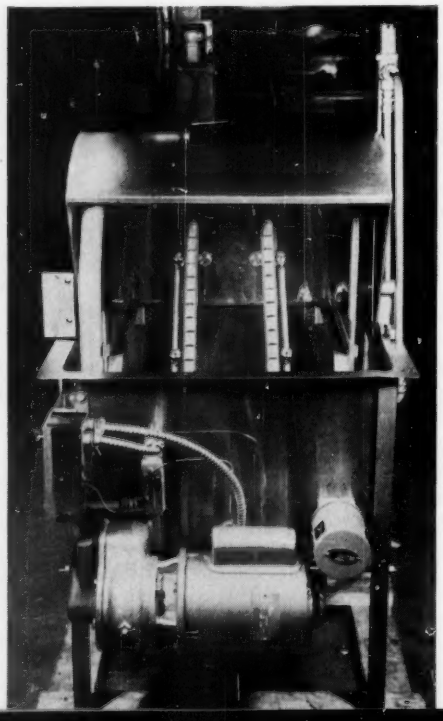


DOOR LOCK:

... with Carpenter Stainless Tubing mechanism. This product offers high resistance to corrosion in and around acid laden atmospheres.

COMMERCIAL DISHWASHER:

Carpenter Stainless Tubing is favored for use in the inlet water manifold, wash spray and rinse tubes of this dishwasher.



TURBO JET ANTI-ICING LINES:

Made of Carpenter Stainless Tubing, these lines— with the use of exhaust gases — prevent jet engines from freezing.

GAS BURNER:

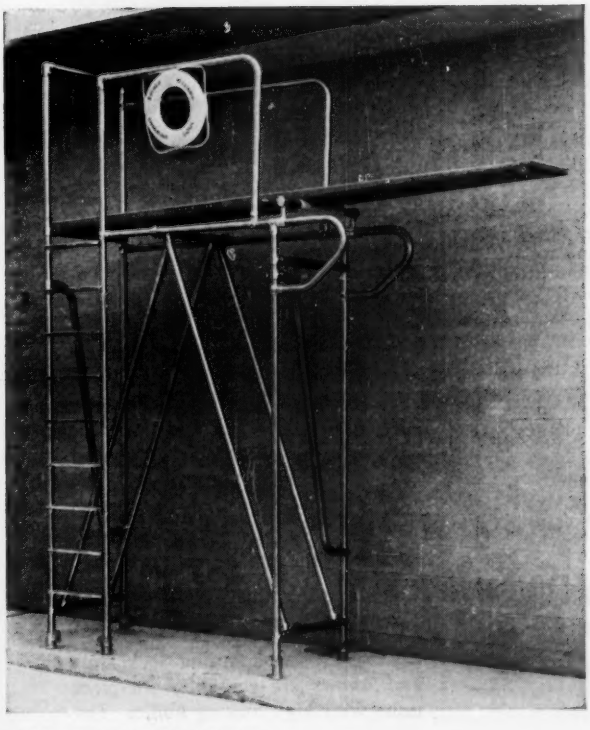
Flame spreader support of Carpenter Stainless Tubing provides freedom of scaling, gives longer life, is maintenance free and withstands high temperature. A flame retention ring also of stainless steel helps eliminate combustion roar.

COFFEE VENDING MACHINE:

Machines like these brew a million cups of coffee per day. Carpenter Stainless Tubing helps assure purity and is easy to clean.

stainless tubing...

for dependable low-cost corrosion control



3-METER DIVING STAND:

Carpenter Stainless Tubing not only beautifies but gives longer life . . . with no maintenance . . . to this aquatic equipment.

• Illustrated are only a few examples of how Carpenter Stainless Tubing is providing added service-life, lightweight strength and dependable low-cost control of corrosion in hundreds of different products. Because it can simplify fabrication of hollow parts and is initially low in cost, Carpenter Stainless Tubing helps cut production costs.

Whenever any equipment component or fabricated part calls for the best combination of Uniform Working Properties • Corrosion Resistance • Close Tolerances • Smooth Surfaces • Better Finishes . . . you can always count on Carpenter Stainless Tubing to meet the need. Contact your resourceful Carpenter Representative for valuable technical and design assistance. In the meantime, send for your guide to lower cost—The Carpenter Selecting and Buying Guide. The Carpenter Steel Company, Alloy Tube Division, Union, N.J.

your master key to cost-saving corrosion control

stainless tubing & pipe

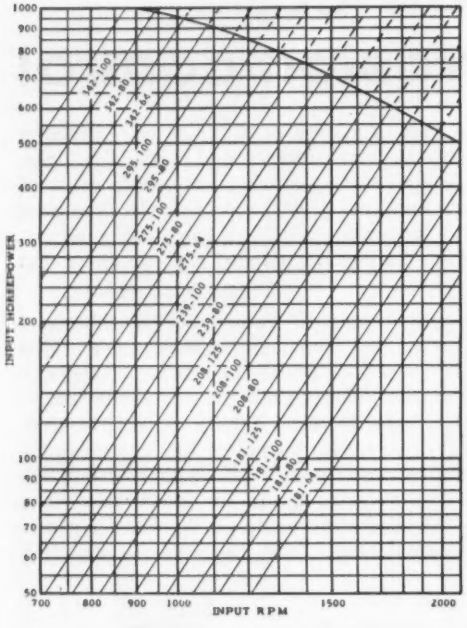
Circle 522 on Page 19

Plan now to DESIGN with National Torque Converters

for Internal Combustion Engine or Electric Motor Applications

The six sizes and 17 hydraulic circuits available in the National Torque Converter line permit the exact matching of converter to internal combustion engines or electric motors from 100 to 1000 hp., and to job. Proper unit can be easily selected on chart below; find input rpm on horizontal scale, input HP on vertical scale. Diagonal area at point of intersection will show size and circuit needed. Curves showing torque-speed ratio for converter you select are available on request.

For more detailed technical information, ask for a copy of Bulletin 468.



Consider these National Torque Converter features

- Simplicity of Design for ease of installation, operation and maintenance
- Full Range of Circuit Sizes permits exact matching to internal combustion engines or electric motors of 100 to 1000 horsepower
- Top Performance enables prime movers to operate at its optimum speed . . . deliver maximum horsepower constantly
- Reproducible Efficiency assures uniform top performance on every job
- Faster Job Cycles means more loads per equipment per operator per day
- Unsurpassed Durability provides longer service life with minimum maintenance

THE NATIONAL SUPPLY COMPANY

Subsidiary of Armco Steel Corporation

TWO GATEWAY CENTER, PITTSBURGH, PA.

(*Continued from Page 185*)

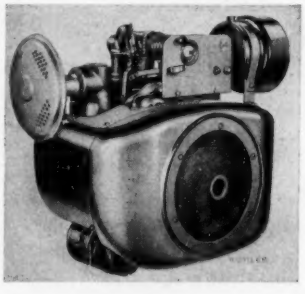
knocked out, and replaced with another. Coupling incorporates a barrel trunnion with milled slot which prevents bolt from turning as nut is tightened. V-band coupling and band are stainless steel; latch and bolt are plated alloy or stainless steel. **Voss Engineering Co.**, 2193 W. 26th St., Cleveland 13, Ohio. G

Circle 687 on Page 19

Compact Engine

for use in small, difficult installations

Redesigned Model K662 engine is a four-cycle, two-cylinder, air-cooled unit with external, high-tension magneto. Tapered roller bearings are provided on both ends of crankshaft. Silence muffler and large-capacity, oil-bath air cleaner have been lowered to reduce overall engine size and to give engine



a compact, small-package appearance. Engine develops 15 hp at 1800 rpm, 20.2 hp at 2400 rpm, 23.4 hp at 3000 rpm, and 24 hp at 3200 rpm. **Kohler Co.**, Kohler, Wis. K

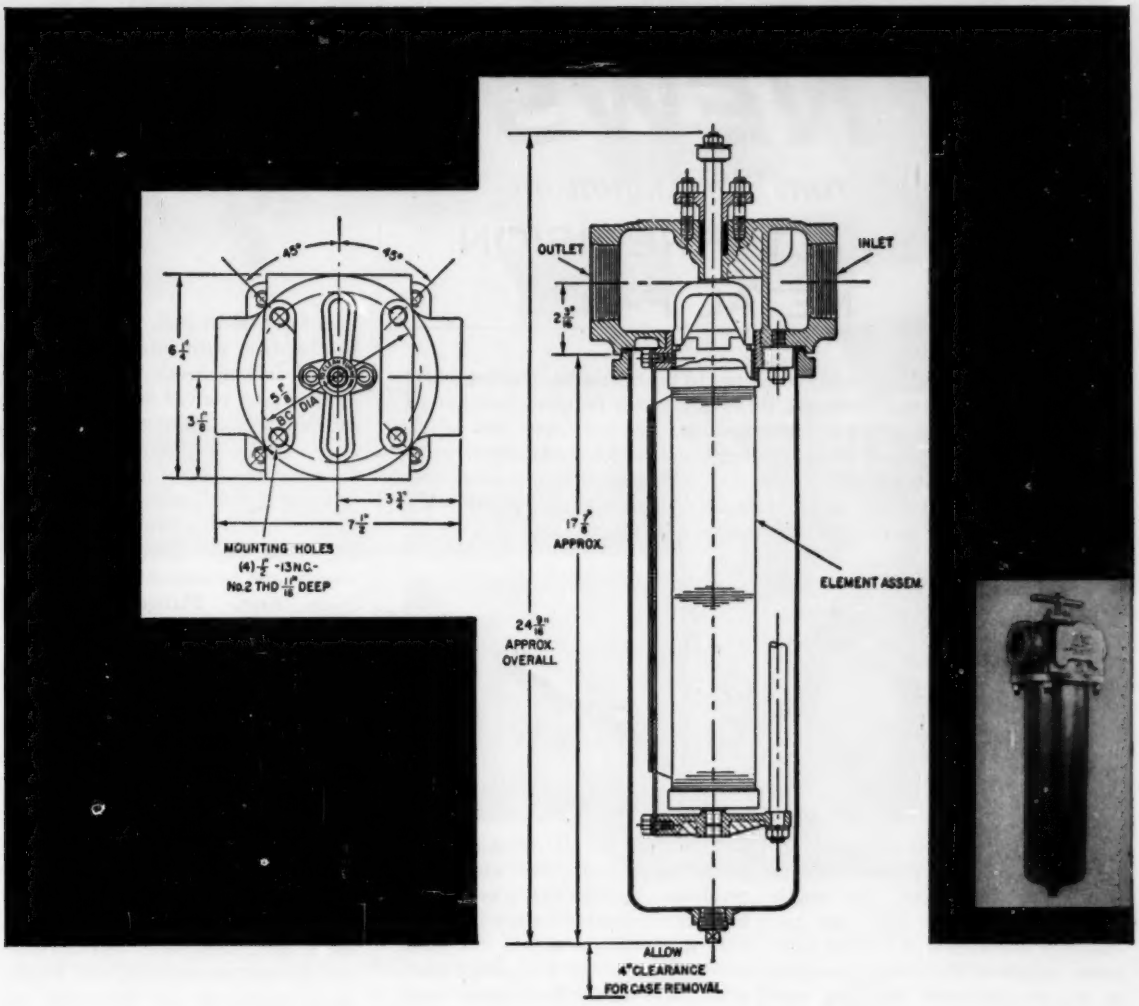
Circle 688 on Page 19

Locking Fasteners

are free-spinning, reusable types

Whiz-Lock free-spinning lock nuts and screws are reusable, one-piece units with high locking ability. The

Circle 523 on Page 19



This one standard Purolator filter is

EXACTLY RIGHT *for all these fluids:*

inks • paints • varnishes • food products • greases • process fluids • fuel and lube oils

SPECIFICATIONS: This Purolator filter model G-141J—is designed for filtration in a range upward of 40 microns.

It can be installed on pressure or suction side of pump.

It is recommended for capacities of from 6 to 200 GPM, dependent on viscosity. Spacing varies from .0010 to .020.

Relief valves set from 10-12 (generally 15 to 20) to 50 PSI are incorporated in several models.

Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical.

Maximum pressure: 125 PSI; weight: 37 lbs. Equipped with simplex full-flow metal element oil strainers.

Available in all stainless steel construction for corrosive liquids, process fluids, food products.

If this filter's specifications recommend it for a problem of yours, write for application information.

Filtration For Every Known Fluid

PUROLATOR

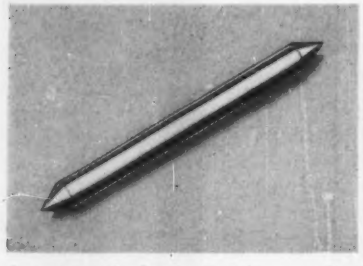
PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Circle 524 on Page 19

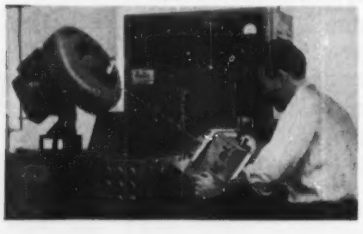
NEWS
from Torrington on
SMALL PRECISION METAL PARTS

"Custom manufacture" has many meanings to the Specialties engineers here at Torrington. One of our customers, for example, may require a part having fairly wide tolerances of several thousandths. The very next job on an engineer's desk may present a real challenge, calling for a complex series of manufacturing operations and a precision measured in ten-thousandths. Torrington's unmatched experience, engineering skills and facilities are ready to serve you *whatever* your particular requirements might be.



A comparatively simple job now going through calls for train axles for HO gage model equipment. The length tolerance is held to .010" and the diameter tolerance is .002". Our engineers complete the whole operation on super high-speed blanking machines designed by Torrington which operate at much greater speeds than available with other commercial equipment. Result . . . substantial savings on a low-cost, high-volume item for our customer.

In contrast to this, a current contract with one of America's leading clockmakers calls for a balance shaft with a diameter tolerance of .0005". If the shaft is supported at the points and rotated, the OD must rise and fall a maximum of .0015" during one revolution. Specialties engineers meet these more demanding specifications with a machine that will cut, form and mill in a single high-speed operation perfected by Torrington. Usual expensive burnishing is replaced by a much faster and far less expensive method to produce a fine finish. Result . . . another example of our ability to adopt new methods in solving a customer's problem economically.

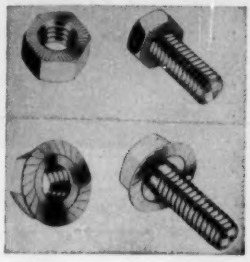


A special engineering department is maintained by the Specialties Division to help you solve any problems involving small metal parts. If required, our highly experienced and skilled engineers will help you design the part for most efficient and economical production. More and more manufacturers are turning to specialized Torrington service. If small precision metal parts are *your* problem, just circle our number on the reply card, call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 626 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings



nuts are heat-treated, high-strength, bearing-type with integrally forged, curved, locking teeth. Curved shape of teeth and convex bearing surface provide a lock which requires much higher wrench torque for release than for application at normal bolt loads. Units deliver controlled torque-tension relationship with high break-loose torque. Nuts and screws are furnished in No. 6 to $\frac{3}{8}$-in. sizes. Flange-type screws and nuts are shown in lower portion of photograph. **MacLean-Fogg Lock Nut Co.**, 5535 N. Wolcott Ave., Chicago 40, Ill. J

Circle 689 on Page 19

Lubrication System

provides quantities as small as 1/135-drop

Miniaturized injector system for automatic lubrication of production machinery, designated Micro-Measure system, premeasures and injects fluid lubricants in quantities as small as 1/135-drop in automatic cycles as often as every minute. Automatically controlled, air-operated pump supplies refinery-pure lubricant to small injectors with micrometer adjustment at a predetermined rate. System maintains constant, uniform oil film on all bearing surfaces with no overflow and no dripping. **Industrial Div., Lincoln Engineering Co.**, 4010 Goodfellow Blvd., St. Louis 20, Mo. I

Circle 690 on Page 19

Cap Nuts

in No. 4 through ½-in. sizes

Cold-headed cap nuts are low-cost units of steel, brass, and aluminum. Sizes range from No. 4 through ½-in. **Jacobson Nut Mfg. Corp.**, Box 177, Kenilworth, N. J. D

Circle 691 on Page 19

Circle 525 on Page 19

Look alikes... until you look closely!

At first glance, all microfilm images look pretty much alike. But enlarge them in a film reader or in paper facsimile form, and you'll see the difference:

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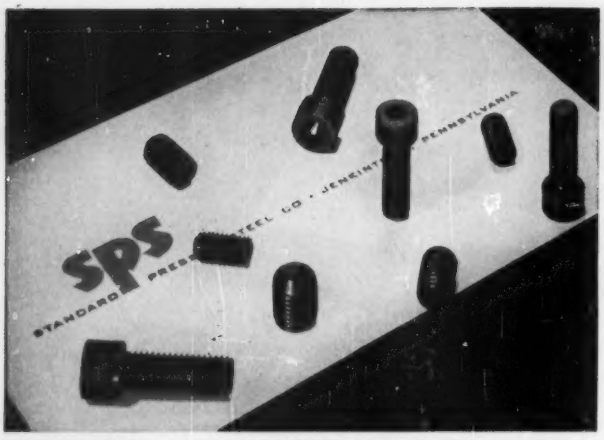


Standard microsize UNBRAKO socket cap and set screws, #0 through #3, are supplied by your authorized industrial distributor in heat-treated alloy or stainless steel. Available with Nylok* self-locking feature.

Microsize UNBRAKO Socket Screws Simplify Fastening of Small Assemblies

Microsize UNBRAKO socket cap and set screws save both time and money in the design and assembly of your small devices. Precision manufactured, available locally, they eliminate the cost and delay of designing or procuring special screws to fasten tiny components. Use them in computers, servomechanisms, instruments, miniaturized electrical and electronic equipment—countless small, intricate devices where reduction in weight and bulk is required without sacrificing strength or reliability.

These miniature socket screws have all the advantages of larger UNBRAKOs. Deep, accurate sockets for non-slip, high-torque wrenching. Radii in socket corners to eliminate sharp angles where cracks start. Fully formed threads for greater strength and precision fit. Controlled fillets under cap screw heads to prevent shearing. Careful heat treat for maximum tensile values without brittleness or decarburization. Because of these features, microsize UNBRAKO socket cap screws are as much as 80% stronger than ordinary miniature cap screws, and microsize UNBRAKO socket set screws can be torqued tighter than ordinary miniature set screws. This extra strength means greater reliability in the fastening of your small assemblies.

For more information, see your authorized SPS distributor. He carries microsize UNBRAKOs in both alloy steel and stainless in sizes #0, #1, #2 and #3. Or write us for Bulletin 2374 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

*T.M. Reg. U.S. Pat. Off., The Nylok Corporation

We also manufacture precision titanium fasteners / write for free booklet

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

HEAT-TREATED ALLOY STEEL
Microsize UNBRAKO Socket Cap Screws
Class 3A Threads

Diameter		Threads per Inch NC	Threads per Inch NF	Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per 1000 in Pounds
#0	A .096		80	1/8		2.0	.21
	B .060		80	3/16		2.0	.22
	D .060		80	1/4		2.0	.26
	F .050		80	3/8		2.0	.33
#1	A .118		72	1/8		3.5	.31
	B .073		72	3/16		3.5	.36
	D .073		72	1/4		3.5	.42
	F .050		72	3/8		3.5	.53
#2	A .140	56		3/16	6.0		.54
	B .086	56		1/4	6.0		.61
	D .086	56		3/8	6.0		.76
	F 1/8	56		1/2	6.0		.91
#3	A .161	48		3/16	8.5		.77
	B .099	48		1/4	8.5		.87
	D .099	48		3/8	8.5		1.07
	F 5/64	48		1/2	8.5		1.27

HEAT-TREATED ALLOY STEEL
Microsize UNBRAKO Socket Set Screws
Class 3A Threads—Plain Cup Point

Diameter		Threads per Inch NC	Threads per Inch NF	Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per 1000 in Pounds
#0	D .060		80	1/16		.5	.03
	F .028		80	3/32		.5	.04
			80	1/8		.5	.05
			80	5/32		.5	.06
			80	3/16		.5	.08
			80	1/4		.5	.11
#1	D .073		72	1/16		1.5	.04
	F .035		72	3/32		1.5	.06
			72	1/8		1.5	.08
			72	5/32		1.5	.11
			72	3/16		1.5	.13
			72	1/4		1.5	.19
#2	D .086	56		1/16	1.5		.05
	F .035	56		3/32	1.5		.07
		56		1/8	1.5		.107
		56		5/32	1.5		.15
		56		3/16	1.5		.19
		56		1/4	1.5		.273
#3	D .099	48		3/32	5.0		.10
	F .050	48		1/8	5.0		.135
		48		5/32	5.0		.18
		48		3/16	5.0		.235
		48		1/4	5.0		.32

HIGH RELIABILITY

SPS research is continually developing fasteners with higher and higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase your overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

Circle 527 on Page 19

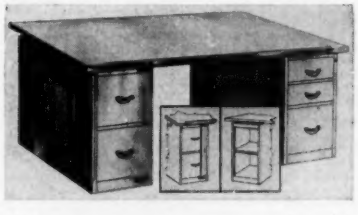
ENGINEERING DEPARTMENT

EQUIPMENT

Engineering Desk

can be assembled quickly without tools

Assemblor 31-in. engineering desk, designed for maximum convertibility and ease of installation, can be changed quickly from a drafting table to an engineering desk. It can be assembled or disassembled in a few minutes without tools. Desk consists of three separate parts with all cross-member supports stored within top. Adjustment tilt bar, when raised, gives 6-deg in-



clination to table top, and folds into top when horizontal desk position is desired. Roll tracing holders on each side of unit hold drawings longer than 72 in. Front edge of drawing board has stainless-steel guard which serves as a tracing protector. **Professional Equipment Div., Hamilton Mfg. Co.,** Two Rivers, Wis. K

Circle 692 on Page 19

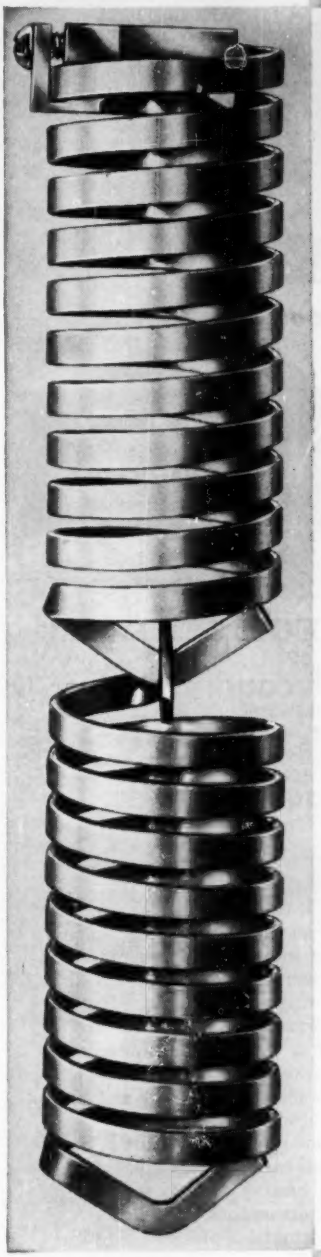
Drafting Film

has high stability and good aging resistance

Flexibility and strength of Cronar base makes Futura drafting paper almost indestructible. It will not tear or crease and cannot crack or yellow with age. Film is available with matte finish on one or two sides. Matte finish is prepared for a wide degree of lead weights without cutting film. Erasures leave no ghost lines or smudges and will not mar surface. Exceptional optical clarity provides for excellent, fast reproduction. Film, packaged in cut sheets

PRECISION TWIN EXTENSION SPRING

Available in practically all sizes and capacities



CHATILLON ISO-ELASTIC* makes this THE WORLD'S MOST ACCURATE SPRING

This type of Chatillon Iso-Elastic Twin Extension Spring is *used by every leading manufacturer of computing scales in the world.* Reason:—because it is *accurate to 1 part in 2,000!*

This extreme accuracy has induced companies like General Electric, Bendix, Pitney-Bowes, Sperry and many others who make precision instruments, to incorporate Chatillon Iso-Elastic springs into their designs.

The hysteresis error of this remarkable spring is less than .05% of deflection. Drift does not exceed .02% of deflection in 5 minutes. Combine these characteristics with temperature compensation and you have what is truly a *precision* spring in every sense of the word. Chatillon makes Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of all conventional alloys.

We can help make your product better. Let Chatillon's Spring Division assist you. Write for engineering bulletins today.

* Chatillon's exclusive temperature-compensated spring material. U.S.A. Pat. No. 2174171.

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Circle 528 on Page 19

VALLEY BALL BEARING MOTORS

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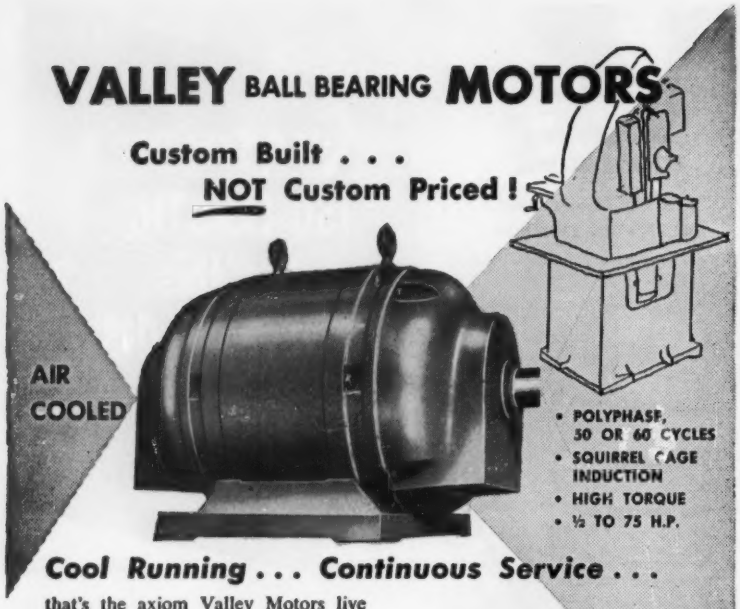
NOT Custom Priced!



Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.

They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

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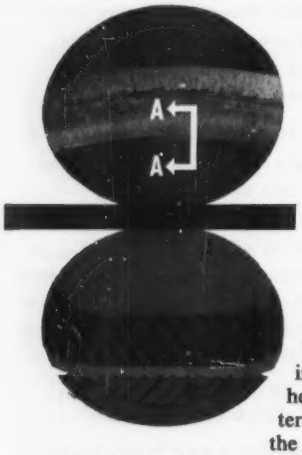
Circle 529 on Page 19



PERFECT SEAL . . .
Teflon* coating mates United's metallic O-ring to surface!

Teflon, permanently bonded to a United metallic O-ring, conforms to normal tool marks which it contacts in a machined seat. This remarkable, non-porous, pliable coating compresses into these irregularities to help form a perfect seal. Spring steel characteristics of the O-ring metal are retained, and the surface conformability of a rubber-like compound is added. Finish is completely non-corrosive and resistant to chemical action. Tests with gases and liquids, at high and low pressures, prove absolute sealing action. United also makes hollow tube; pressure-filled; and patented† self-energized metallic O-rings; and wire and brazing O-rings to practically any required dimensions. Write for information (on your letterhead please).

TOP: Tool marks visible in TEFLON coating, magnified 12X.

BOTTOM: Section A-A TEFLON . . . conforms to irregularities in machined surface.

*TEFLON IS THE REGISTERED TRADEMARK FOR DUPONT TETRAFLUOROETHYLENE RESINS. † PATENTS 2,809,269; 2,837,360

UNITED METALLIC "O" RING CORP.
Dayton, Ohio • Box 1035
Division of United Aircraft Products, Inc.

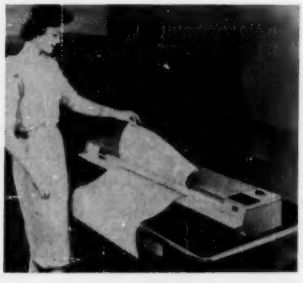
Circle 530 on Page 19

and rolls, is 0.004-in. thick. **Chart-Pak Inc.**, One River Rd., Leeds, Mass. B

Circle 693 on Page 19

Reproduction Machine

diazo-type unit makes tracings to 42 in. wide



Low-cost diazo-type reproduction machine, Copyflex Model 42, makes sharp, positive prints and tracings up to 42 in. wide by any length. Developer is available in a spray applicator, and is odorless and free of noxious fumes. Mechanical speed range is from 3 to 36 ipm. Unit, which measures 6½ in. high by 12 in. deep by 56 in. long, is suitable for use on a table or hanging from a wall. **Charles Bruning Co. Inc.**, Mt. Prospect, Ill. J

Circle 694 on Page 19

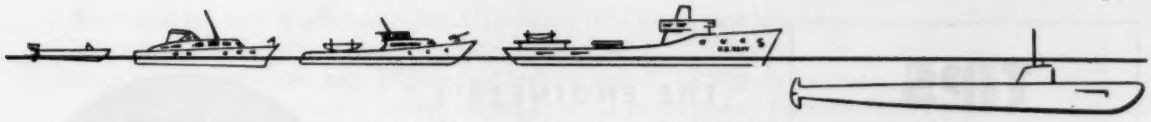
Expanded-Scale Voltmeter

has accuracy of ±0.5 per cent

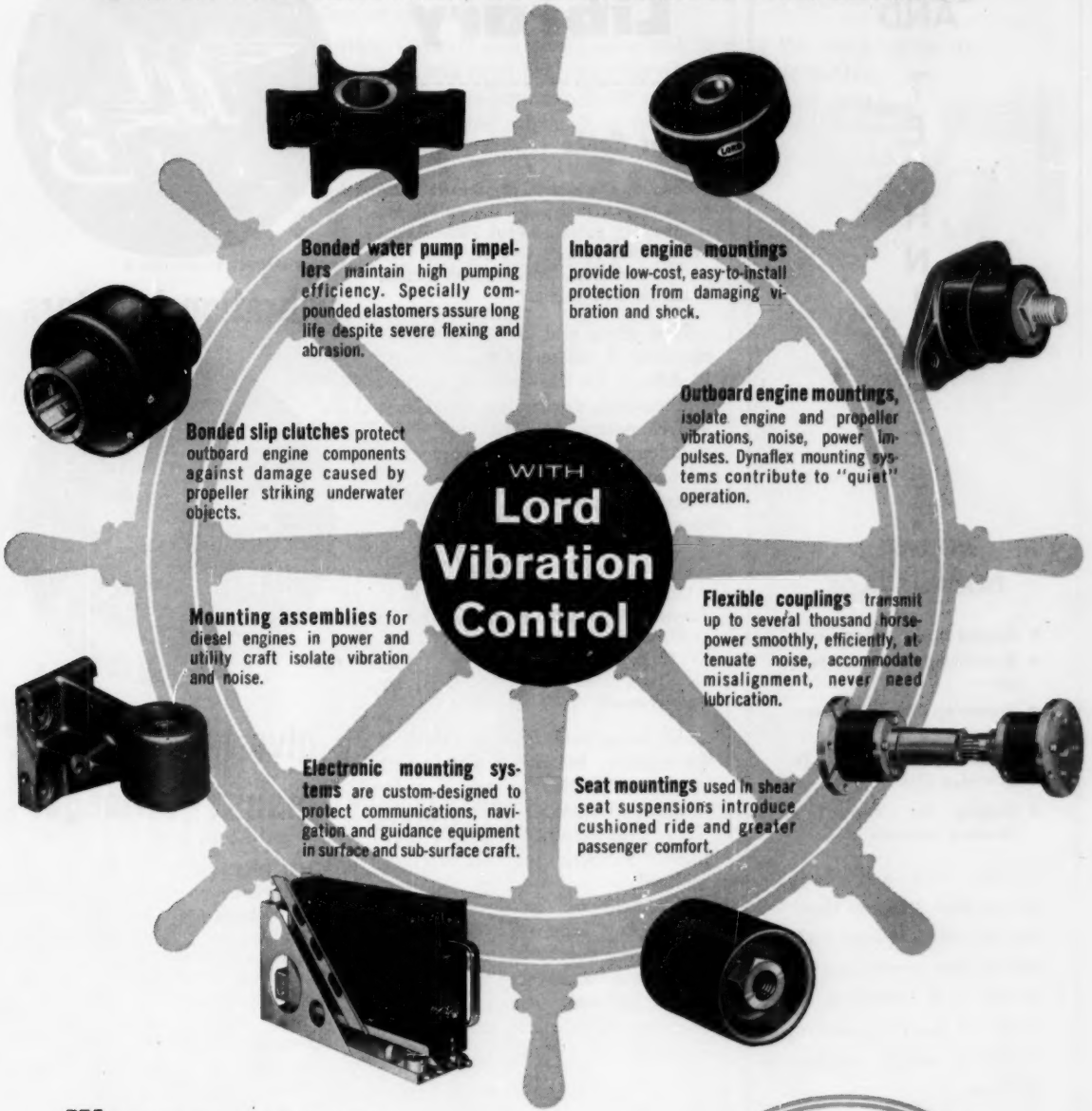
Expanded-scale voltmeter is available in both panel-mounted and cased units. Features include ±0.5 per cent accuracy, high input impedances of 1000 to 1700 ohms per volt,

and scale expansions of 4:1 or greater. Both ac and dc models are available, and no external power source is required. **Magnavox Co.**, Dept. NP, 2131 Bueter Rd., Ft. Wayne, Ind. J

Circle 695 on Page 19



DESIGN FOR SMOOTHER, QUIETER MARINE PERFORMANCE



Bonded water pump impellers maintain high pumping efficiency. Specially compounded elastomers assure long life despite severe flexing and abrasion.

Inboard engine mountings provide low-cost, easy-to-install protection from damaging vibration and shock.

Bonded slip clutches protect outboard engine components against damage caused by propeller striking underwater objects.

Outboard engine mountings, isolate engine and propeller vibrations, noise, power impulses. Dynaflex mounting systems contribute to "quiet" operation.

Mounting assemblies for diesel engines in power and utility craft isolate vibration and noise.

Flexible couplings transmit up to several thousand horsepower smoothly, efficiently, attenuate noise, accommodate misalignment, never need lubrication.

Electronic mounting systems are custom-designed to protect communications, navigation and guidance equipment in surface and sub-surface craft.

Seat mountings used in shear seat suspensions introduce cushioned ride and greater passenger comfort.

What is your design objective?
Quieter operation? Less maintenance? Cost savings?
Improved personnel comfort? Fewer component failures?

You can utilize LORD capabilities in vibration/shock/noise control to realize these and other performance advantages for your marine equipment. LORD-engineered systems isolate undesired disturbances, enabling you to obtain vital competitive advantages.

For authoritative assistance on vibration/shock/noise problems, consult LORD. Contact the nearest Field Engineering Office or the Home Office, Erie, Pa.

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TIPS AND TECHNIQUES

VOLUME I

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THE ENGINEER'S Library

Recent Books

Concise Dictionary of Science. *By Frank Gaynor; 546 pages, 5½ by 8¼ in., clothbound; published by Philosophical Library Inc., 15 East 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, *$10.00 per copy postpaid.*

New terms and extensions of the meaning of old terms are accurately defined for the fields of physics, mathematics, nucleonics, astronomy, and chemistry. Also included is terminology for such new branches of science as virology, enzymology, cytogenics, radiochemistry, and high-energy and solid-state physics.

Filler Metals for Joining. *By Orville T. Barnett; 244 pages, 6 by 9 in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$7.00 per copy postpaid.*

All recognized filler metals used for welding, brazing, and soldering are discussed. Reasons are given for selecting the proper filler metal for any metal-joining situation, and present industrial practices are summarized.

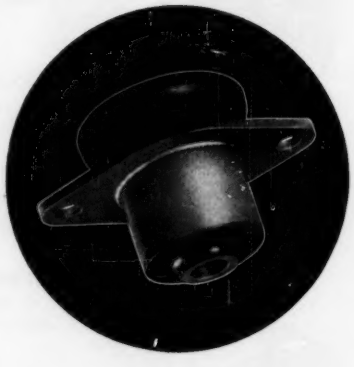
Specifications, color-coding, and engineering experience from many sources are combined in this book. New areas such as iron-powder electrodes, automatic welding wires, and soldering filler alloys are discussed in detail.

New Standards

Bolt, Nut and Rivet Standards. *287 pages, 5¼ by 8½ in., clothbound; available from Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13, Ohio; $3.00 per copy.*

This third edition covers fastener products that are practical and economical to manufacture, readily available, and interchangeable when obtained from different manufacturers. While most of the standards were developed by the American

vibration isolators



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MB ISOMODE® mounts break endurance records. Despite heat, road shock and hard operating conditions in bus service, engine mounts removed for critical inspection after 132,000 miles were still good. To such durability add the superior vibration isolation afforded by a mount that controls vibratory motion in all directions.

MB concentrates on standard mounts which are actually in the special performance class. If you have a problem, avail yourself of our 20 years of experience. Send for Bulletin 616A which tells more.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.

1056 State Street

New Haven 11, Connecticut

Circle 533 on Page 19

NEW in looks, new in efficiency, and forerunner of a great new line of MB vibration exciters... that's the new Model C125.

Once again leading the way, MB has achieved a radical step-up in magnetic circuit efficiency. This new shaker, barely larger than its predecessor, develops 10,000 pounds force output... a 43% gain! Conversely, it calls for less amplifier power than any other electrodynamic shaker of comparable force.

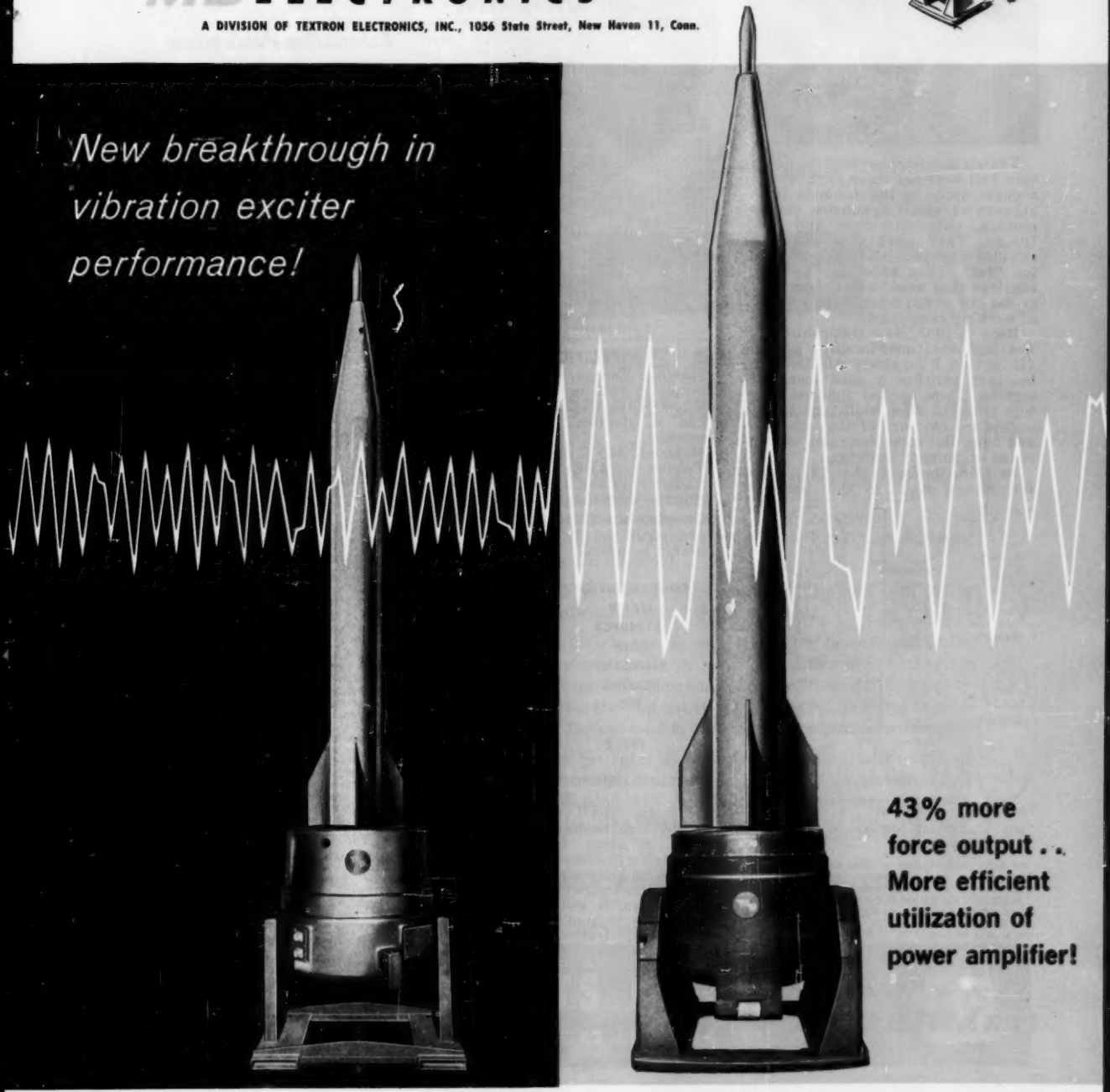
Leading companies in missiles, aircraft and electronics look first to MB for progress in complete vibration test systems. It has been that way for almost 15 years. Our "encyclopedia" of vibration experience is yours to draw on... as is the largest, national, field service staff of specialists. Send for full data.

Pioneer and leader in the field of vibration

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC., 1056 State Street, New Haven 11, Conn.

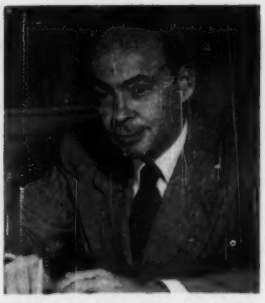
New breakthrough in vibration exciter performance!



43% more force output... More efficient utilization of power amplifier!

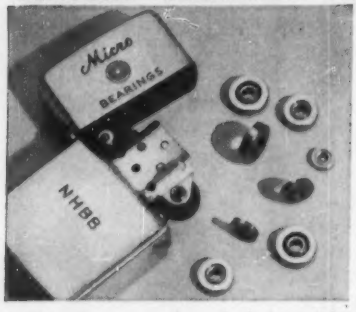
Circle 534 on Page 19

BEARING ABSTRACTS



by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings

NEW NHBB WAFER BEARINGS FEATURE NARROWER WIDTHS



There's a new, lean look in miniature ball bearings these days. It was brought about by the demands of designers of small synchros, servos, motors, potentiometers and gear trains. They said that standard shielded miniature bearings were much too "fat". They asked for "skinny" bearings that would allow them to increase the width, strength or capacity of working components.

Back in 1955, New Hampshire Ball Bearings, Inc., introduced its UP line (U for thin, P for single shield). These bearings satisfied a good many designers. These special shielded bearings have the same width as standard unshielded bearings of the same O.D. and bore. But some designers still insisted on thinner bearings.

In 1958, they got what they asked for. A new series of thin bearings, called NHBB Wafer was introduced. These light bearings offer the advantages of widths as much as 40% narrower than standard unshielded bearings of the same O. D. and bore, as illustrated in *Fig.* 2.

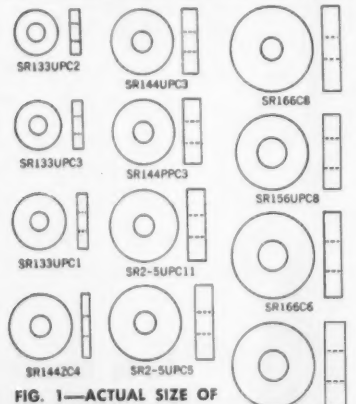


FIG. 1—ACTUAL SIZE OF NHBB WAFERS

The space-saving feature of these new NHBB Wafer bearings has been welcomed particularly by designers of small servos, synchros and motors. It permits miniaturization to be carried a step farther when smaller packages are required. In other cases, the narrower bearing widths allow the addition of more iron or copper to rotors and stators without changing package size. This means that greater capacity and improved performance can be built into existing designs.

TWELVE NEW NUMBERS

NHBB Wafer bearings are now available in twelve numbers: seven with single shields, one with two shields and four unshielded, as charted below.

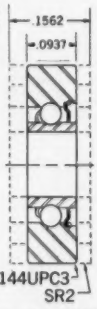
NUMBER	BORE	O.D.	WIDTH
SR133UPC2	.0937	.2500	.0625
SR133UPC3	.0937	.2750	.0625
SR133UPC1	.0937	.3125	.0625
SR144ZC4*	.1250	.3750	.047
SR144UPC3	.1250	.3750	.0937
SR144PPC3**	.1250	.3750	.1094
SR2-5UPC11	.1250	.4250	.1094
SR2-5UPC5	.1250	.4375	.1094
SR166C8	.1250	.5000	.1094
SR156UPC8	.1875	.4375	.1094
SR166C6	.1875	.5000	.1094
SR166PC7	.1875	.5000	.1250

*Unshielded, spring separators
**Two shields

SPECIFICATIONS

Starting Torque: Standard starting torque is 1400 mg mm under 75 gm thrust, 90% guaranteed at 1100 mg mm if specified. Lower levels by selection.
Material: 440 C stainless steel.
Tolerances: ABEC7 or better.
Radial Play and Lubrication: as specified by customer.

Complete specifications are contained in one design handbook.



COMPARISON OF WAFER 5R144UPC3 WITH STANDARD BEARING SR2

FIG. 2

DESIGNERS HANDBOOK FREE TO ENGINEERS

If you work with miniature ball bearings, you'll find this 80-page authoritative handbook a great help in solving problems in designing instruments or electro-mechanical assemblies. It will be sent free to qualified engineers, draftsmen and purchasing agents. Write:

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Standards Association, others were prepared by the Institute through efforts of users and both member and nonmember manufacturers.

Included is information on studs, plain washers, cotter pins, fastener materials and processes, and application data. Other sections cover grade markings, terminology and abbreviations, weight tables, and a list of fastener specifications and standards.

Association Publications

Arc Welded Joints. *By La Motte Grover; 46 pages, 6 by 9 in., paperbound, stapled; published by Arc Welding Section, National Electrical Manufacturers Association, 155 East 44th St., New York 17, N. Y.; available from American Welding Society Inc., 33 West 39th St., New York 18, N. Y.;* $0.25 *per copy.*

Principles are presented for design and calculation of stresses and strengths of arc welded joints and connections. Terminology and symbols conform to American Welding Society standards. Terms are defined, and symbols for types and sizes of arc welds and plate-edge preparation are described. Sketches and photos illustrate arc welding processes and clearances required for welding equipment and operators.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 131963. Fundamental Mechanism of Wear and Friction of Unlubricated Metallic Surfaces at High Sliding Speeds. By Fred M. Sauer, for Naval Ordnance Test Station; 55 pages, 8 by 10½ in., paperbound, side-stapled; **$1.75** per copy.

Experimental program and theoretical study are reported for material properties governing wear and for relationships between load, wear, coefficient of friction, and velocity. Twenty-three runs were made with a captive, rocket-propelled sled pushing test shoes on a track. Type 304 stainless steel and molybdenum shoes were used with loading pressures of 160 to 1600 psi and velocities of 600 to 790 fps.

PB 151459. The Mechanical Properties of Certain Aircraft Structural Metals at Very Low Temperatures. By Robert L. McGee, James E. Campbell, Robert L. Carlson, and George K. Manning, for WADC; 57 pages, 8¼ by 10¾ in., paperbound, stapled; **$1.75** per copy.

Nine alloys tested were 17-7PH and AM-350 stainless steel sheet stock, AISI 4340 and Tricent steel bar stock, 7079-T6 aluminum-alloy billet, ZK60A-T5 magnesium bar stock, and A110AT, C110M, and 6Al-4V sheet titanium alloys. Test temperatures were room temperature, —78 C, —196 C, and —253 C (in liquid hydrogen). Data obtained were for yield strength, tensile strength, elastic modulus, breaking strength, elongation, area reduction, and notched strength. Charpy impact data and Vickers hardness values are included.

Circle 535 on Page 19

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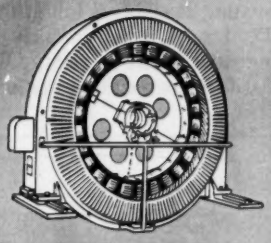
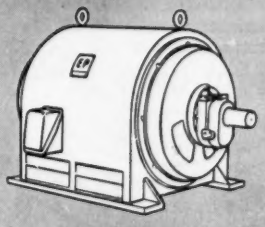


SYNCHRONOUS MOTORS
20-5000 HP
ASK FOR BULLETIN 43-205



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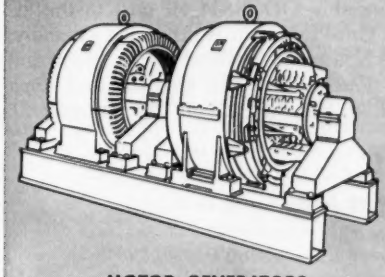
60-1750 HP
ASK FOR BULLETIN 37-200



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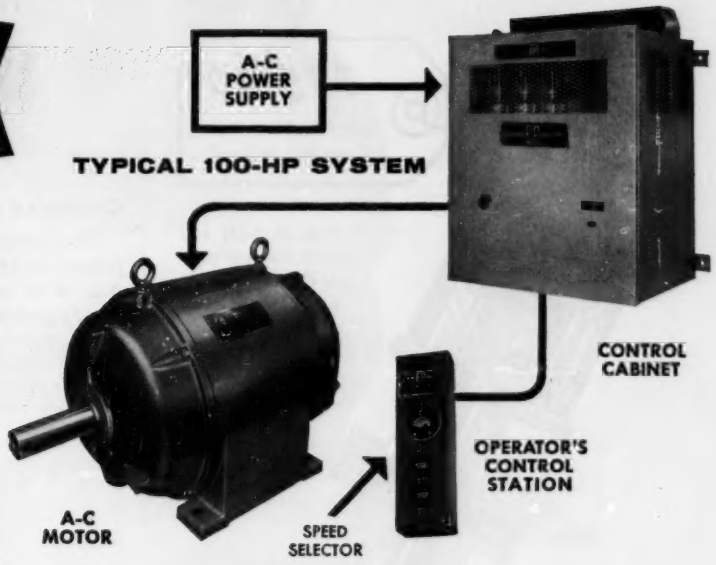

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Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members – saves coil burn-out
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Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

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CONTROL VALVE DIVISION **Barksdale valves**

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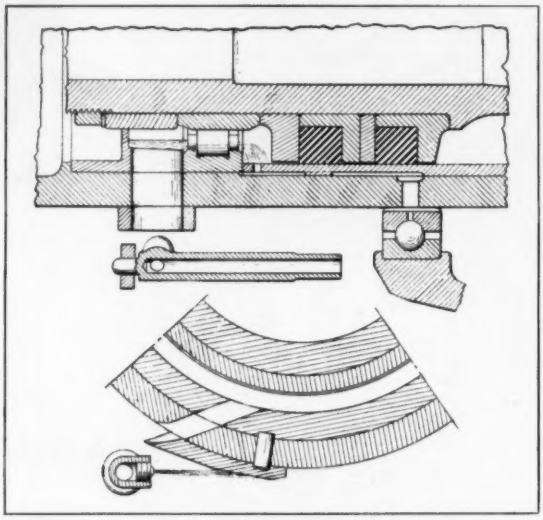
NOTEWORTHY

Patents

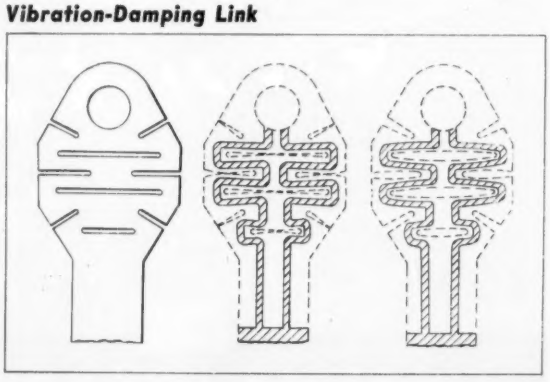
Channeled Oil-Mist Lubrication

The interior of a rotating assembly is lubricated, from points outside its OD, through nozzles which direct a mist of oil nearly tangential to the assembly OD. Mist speeds as high as 41,000 in. per minute minimize loss



of oil through input channels due to centrifugal force. Scoops on the assembly OD direct oil mist to the assembly interior. Once lubricant is inside the assembly, centrifugal force is used to channel oil to plain and roller bearings. *Patent* 2,878,894 *assigned to United Aircraft Corp., East Hartford, Conn, by Kenneth D. Andrews.*

Vibration-Damping Link



Narrow slots in a link absorb vibrations in two bodies which the link connects. The link is particularly suitable when the connected bodies have high inertia and

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Circle 538 on Page 19

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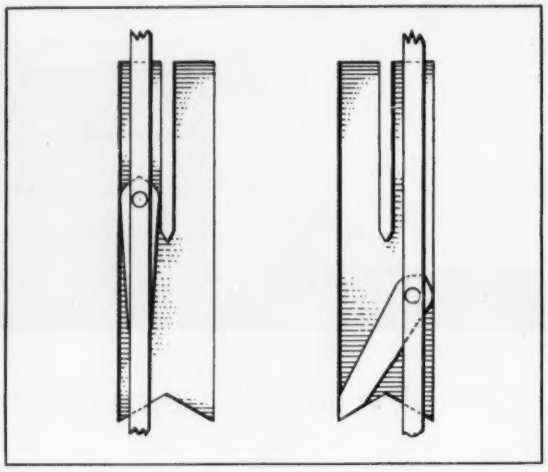
when their vibration frequencies are different and out of phase. Preferably, the link is made of textile laminations. *Patent 2,882,748 assigned to I-T-E Circuit Breaker Co., Philadelphia, by John Parstorfer.*

Alternating-Position Actuating Rod

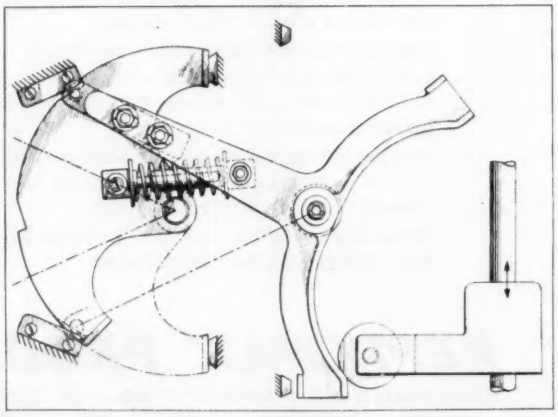
Action of a switching pawl connected to a reciprocating rod enables the rod to make contacts alternately and continuously along two parallel positions of the



rod center line. As the rod moves downward, its pawl bottoms in wedge surfaces and cams the rod to a second position parallel to the first. The next time the rod moves downward, the pawl bottoms in a second wedge and returns the rod to its first position. *Patent 2,865,496 assigned to Harris-Intertype Corp., Cleveland, by Franz Schonenberger.*

Snap-Action Reversing Mechanism

Snap action motion reversal is provided in a traverse mechanism by a spring-loaded, telescoping subassembly

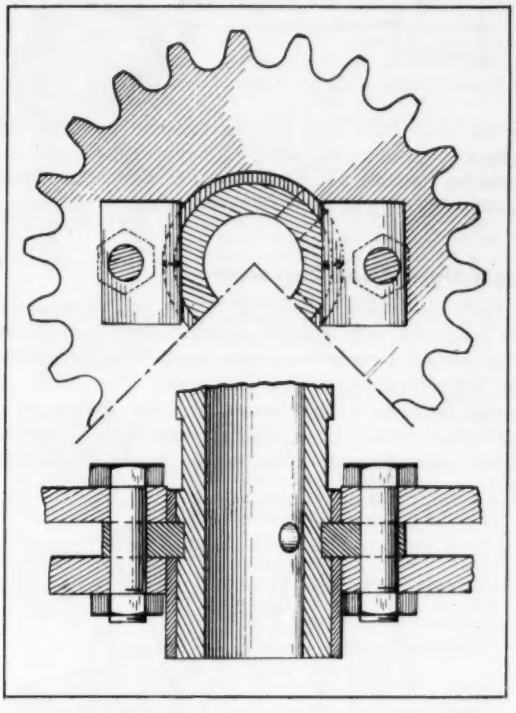


connected between a T-shaped actuating lever and a sector-shaped ratchet plate. At limits of its travel, the ratchet plate is held in place by latches. The

actuating lever is moved continuously under control of a traversing follower. At limits of actuator travel, a pin on the tail of the actuator disengages ratchet-plate latches. Then the telescoping connector snaps the ratchet to its other limit. At the instant of unlatching, the spring in the connector is at maximum compression. *Patent 2,886,974 assigned to American Viscose Corp., Philadelphia, by Ernest K. Bauer.*

Transverse Shaft Keys

Power-transmitting gears or sprocket wheels are prevented from turning about their shaft by two blocks



which seat in keyways perpendicular to the shaft axis. The blocks also prevent displacement of the wheels along the shaft. Bolts which join the assembly also provide frictional resistance to prevent slipping of the blocks about bolt axes. *Patent 2,883,217 assigned to Hesston Mfg. Co., Hesston, Kansas, by Allen A. White.*

Thrust-Compensated Vibrator Assemblies

Geometry of contact elements in a pendulum vibrator design eliminates or substantially reduces thrust along the axis common to stationary bearing members in the vibrator assemblies. This thrust is a component of pressure normal to the moving lines of contact between conical surfaces of the roller track and the roller body. Counterthrust is generated by the tendency of pendulum shafts to twist. Pendulums which carry roller bodies, *a* and *c*, and those which carry roller races, *b* and *d*, must have counterthrust in opposite directions. To assure correct direction of counterthrust, whether pendulum shafts are flexible or rigid, apexes of cones

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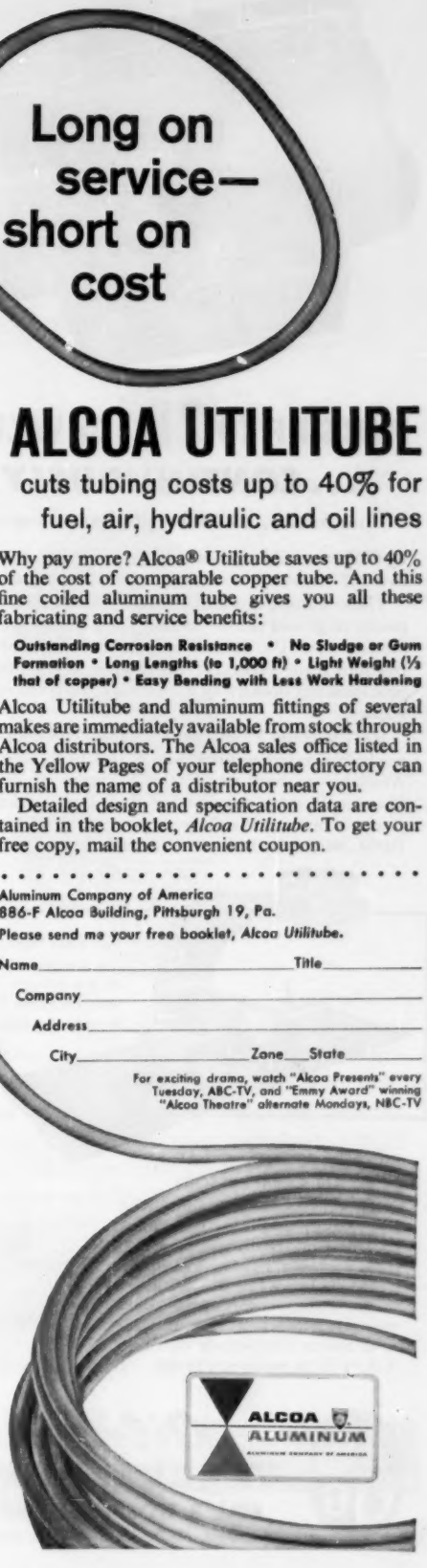

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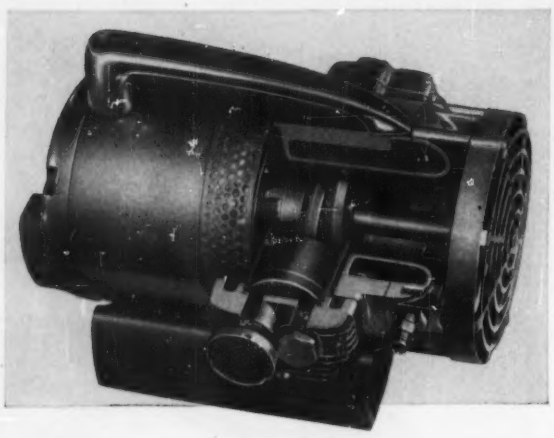

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no messy, oil-laden discharge vapors

B&G Vacuum Pumps are *oil-less* units that will pull up to a 28" vacuum—not intermittently but *continuously!*

These pumps are constructed with carbon-graphite piston rings and skirts—bearings are grease packed and *lubricated for life.* This oil-less operation not only means freedom from expensive maintenance and lubrication problems but does away with messy, oil-laden discharge vapors.

B&G Vacuum Pumps are extremely compact—can be easily integrated with equipment and machinery designs. Available as bare dry Vacuum Pumps or dry motor Vacuum Pumps, powered by B&G-built, quiet, vibration-free motors, displacements to 6.57 CFM at 1725 RPM. Write for Bulletin GO-259.

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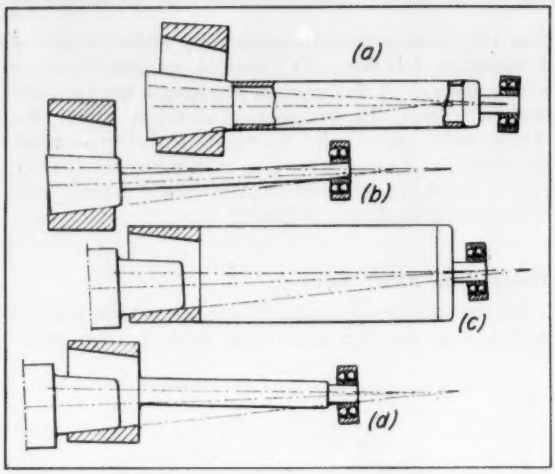
BELL & GOSSETT COMPANY

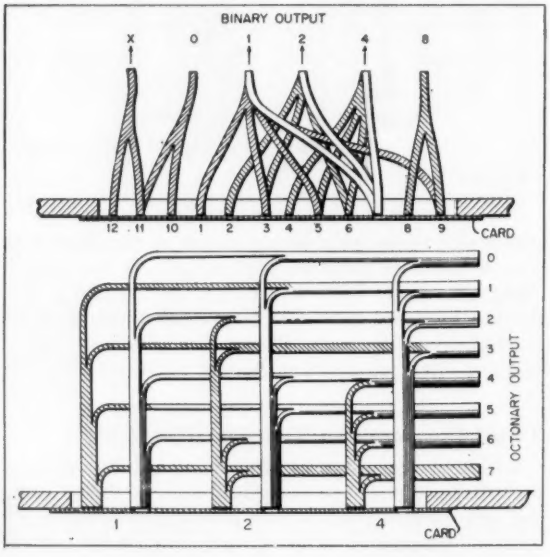
Dept. FT-67, Morton Grove, Illinois



in the roller-body type fall short of end bearings, and apexes of cones in the roller-race type fall beyond end bearings. *Patent* 2,881,620 *assigned to Vibro-Plus Corp., Woodside, N. Y., by Sven-Ake Nordegren.*

Light-Signal Code Converter

Light-channeling tubes, of Lucite or like material, are combined into matrices which convert information from punched cards into other kinds of codes suitable for information-processing machines. The cards are passed between a light source and the inlet ends of individual tubes. In a "light" condition, functional light passes through holes in the cards. This is the



case when the output is binary, that is, more than one output indication for each input indication. The cards block transmission in a "no light" arrangement in which several inputs are required for each output indication. *Patent* 2,881,976 *assigned to International Business Machines Corp., New York, by Evon C. Greanias.*

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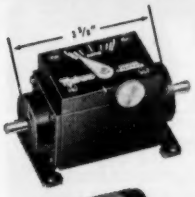
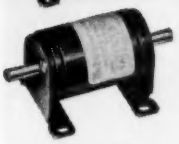
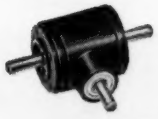


SERIES 2
Adjustable Speed Ratios...continuously adjustable over a 25:1 range (1:5 up to 5:1 down). Handles torques 5 to 40 oz.-in. depending on ratio setting; speeds up to 10,000 RPM; power to 0.025 HP. Your choice of worm gear, spur gear, thumb screw, lever or miter gear adjustment.



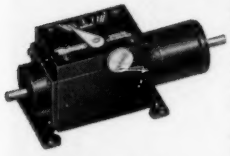
SERIES 8
Fixed Ratios...Over 400 standard ratios from 1:1 to 531,441:1. Handles torques up to 24 oz.-in. at low speed shaft; speeds to 10,000 RPM at high speed shaft; power to 0.025 HP at low speed shaft. Backlash only 2 to 4 degrees at low speed shaft.

SERIES 9
Anti-Backlash...Same as Series 8 above, except this unit changes speeds with little or no lost motion. Backlash held to 15 minutes or less at low speed shaft. Handles torques up to 12 oz.-in. at low speed shaft.



SERIES 12
Angle or T-Drive...Transmits power at right angles. Handles power up to 0.025 HP; speeds to 10,000 RPM; and torques to 24 oz.-in. Ratio is 1:1.

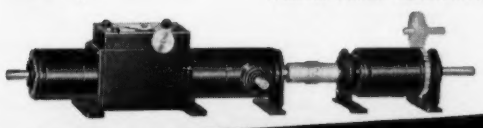
T-DRIVE AND SERIES 8 COMBINATION
Speed Reducer Plus Angle or T-Drive...Transmits power at right angles. Changes speed by fixed ratio.



SERIES 2 AND SERIES 8 COMBINATION
Adjustable Ratio Plus Fixed Ratio...Extends range over which speeds may be adjusted continuously. Add one or more fixed ratio speed changers to obtain range you require.

SERIES D8 OR D9
Differential...Adds or subtracts two rotating or angular inputs. Controls relative speeds; gives wide range of ratios; reverses or stops quickly without disconnecting shafts.

Here's how Metron units can combine without modification.



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Circle 542 on Page 19

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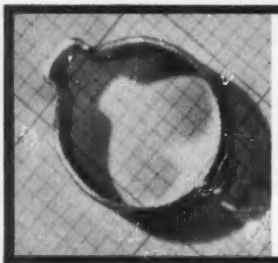

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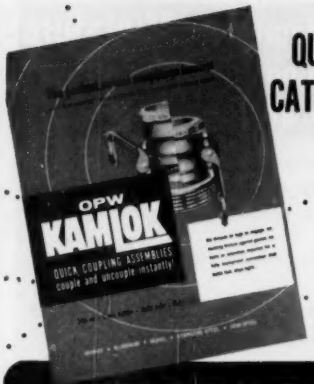

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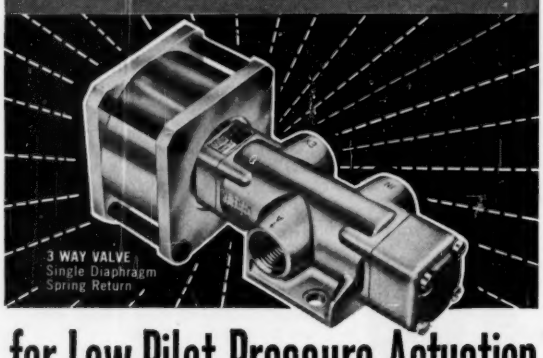
VERSA Diaphragm Actuated Valves



for Low Pilot Pressure Actuation

Versa Diaphragm Valves can be actuated by pilot (or signal) pressures as low as 5 PSI on double diaphragm types and as low as 10 PSI on standard spring return models.

Versa Diaphragm Valves are available with side port bodies or for manifold mounting, and in sizes from 1/8" thru 1" NPT in 2-, 3-, 4-, and 5-way types, and for pressures from partial vacuum to 500 PSIG.

All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness.

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BROOKLYN 6, N. Y.

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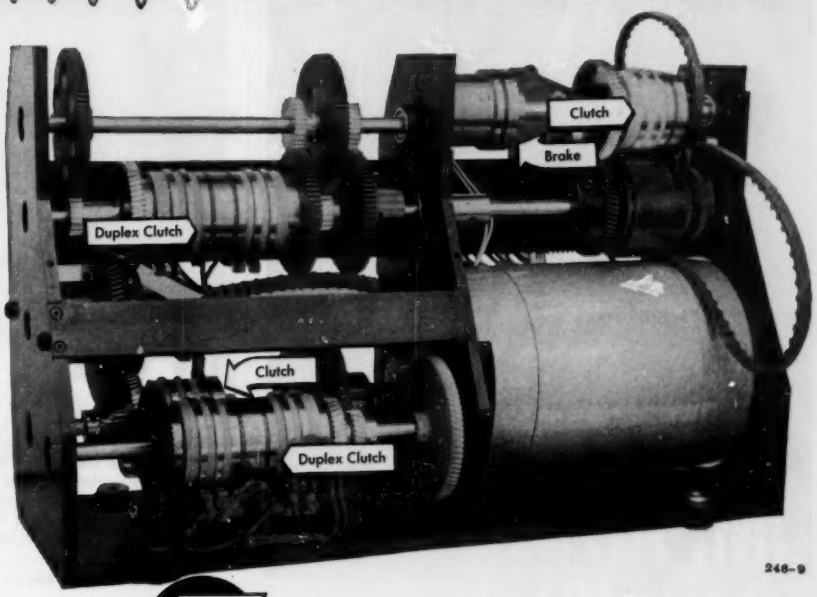
...In New HONEYWELL VISICORDER® OSCILLOGRAPH



246-9

Here you see a classic illustration of the adaptability and versatility of Simplatrol Electric Clutches and Brakes. In this new Honeywell Model 1012 Visicorder Recording Oscillograph two sets of Simplatrol Duplex clutches, two Simplatrol clutches and one Simplatrol brake form a compact, swift, silent and sure "team".

The Heiland Division of Minneapolis Honeywell has set an extremely high standard of speed and accuracy for this clutch and brake installation. Simplatrol has met the challenge.

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Ask for special Simplatrol literature on large, miniature and small and fixed field clutches and brakes.

Simplatrol products corp.
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Representation in Key Industrial Areas

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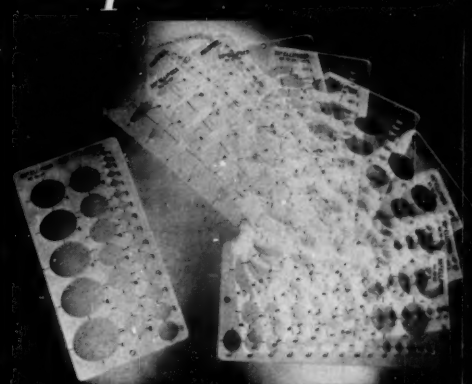

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ATTENTION HEAVY EQUIPMENT DESIGNERS!

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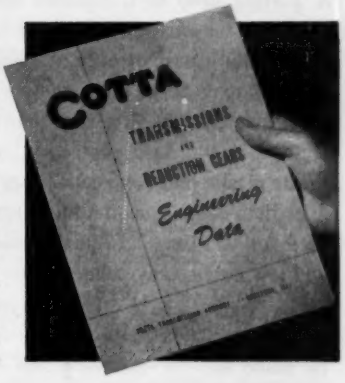

Do you use transmissions with input torque capacities ranging from 150 to 2500 ft lbs? Then you'll want this handy reference book that puts design information right at your fingertips—gives you examples of single speed, multiple speed and right angle drive transmissions.

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- fully dimensioned engineering drawings of 15 transmissions and reducers
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Company _____
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City _____ Zone _____ State _____

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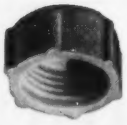

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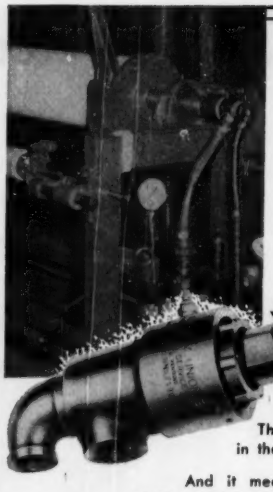

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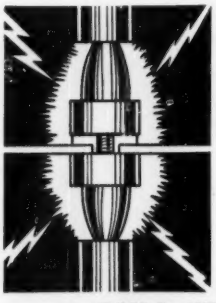

Note the strong dual line projections and precision pilot for easy locating

Note how the projections coalesce with parent metal providing a permanently positioned primary fastener

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FOR FASTER AND BETTER JOINING OF YOUR PRODUCT COMPONENTS

This nut, which is applied by resistance welding, becomes the PRIMARY FASTENER in fastener assemblies. It offers these distinctive advantages:

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Samples and information furnished upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.
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CASTING TO STAMPING saves 55%

Originally this grey iron casting required expensive milling and drilling operations. In 350 lots the piece price was $1.18 plus pattern, milling fixture and drill jig charges.

Converting to a stamping formed from 12 gage sheet steel cut the piece price to 53c *including tooling.* The present stamping is lighter, stronger, better duplicated and improved over-all.

Bulletin F-185 explains this highly efficient, specialized technique for cutting the work load and costs of metal fabricators. Write for it today.

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Manufacturing Company

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- *Excellent compression — deflection*
- *Outstanding compression set*
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Leader in fabrication of silicone rubber products.

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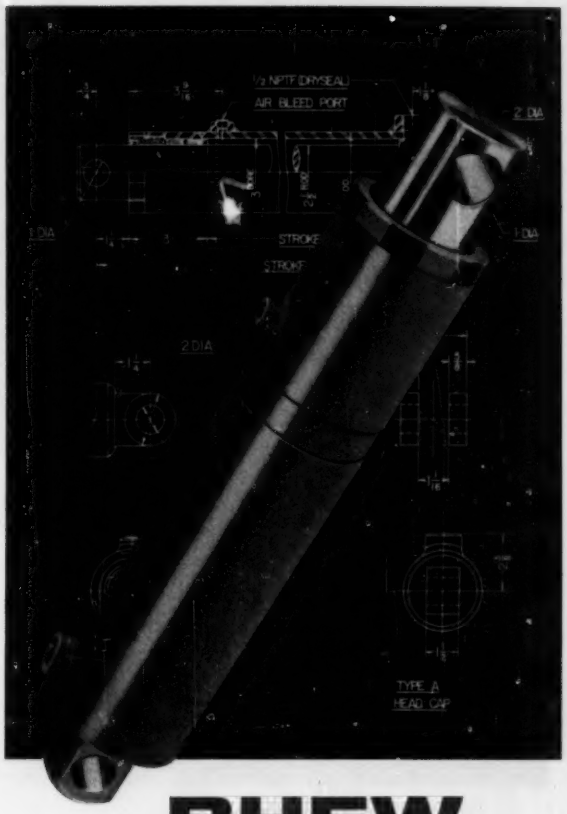

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NOW!

MINIATURE AGASTAT®

time/delay/relay

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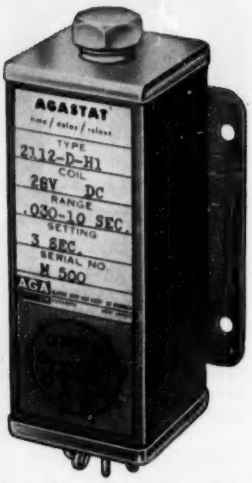

The Miniature Agastat time delay relay is a space-saving answer to aircraft, missile and computer problems. You get all these valuable features in one small package:

- Easily adjusted timing ranges as short as .030 seconds.
- Repeat accuracy of ± 5%.
- Time delay on energizing or de-energizing.
- For DC or AC operation.
- Hermetically sealed or dust-proof housings.

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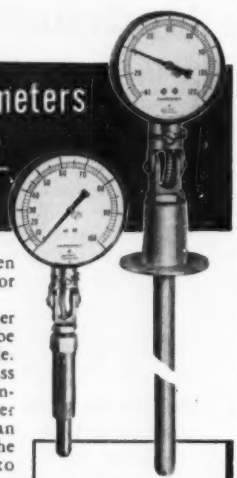
New!

Marsh Dial Thermometers *designed expressly* for piping and ducts



Here you have everything that has been so long needed in thermometers for piping and duct work.

Big 3½" and 4½" dials are far easier to read; still more important, can be turned and tilted to *any* reading angle.

Instead of illegible, breakable glass tube, you now have the readable, unbreakable Marsh—the thermometer that gives greater *readable* accuracy than any glass tube thermometer and has the famous Marsh "Recalibrator" to *keep* it accurate.

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New bulletin covers interesting details

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EASY AS IT LOOKS!
NEW ADD-A-UNIT MANIFOLDS WITH ELECTRICAL PLUG-INS SIMPLIFY MULTIPLE AIR INSTALLATIONS

Consider the advantage of single manifold units—as a standard stock item—which allows you to design and build your own manifolds of from two to ten valves. And with electrical plug-ins the body simply plugs onto the base to complete the wiring. Write for information on the revolutionary 4-way Dual-Seal air valve. ¼", ⅜", ½" port sizes.

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MAC

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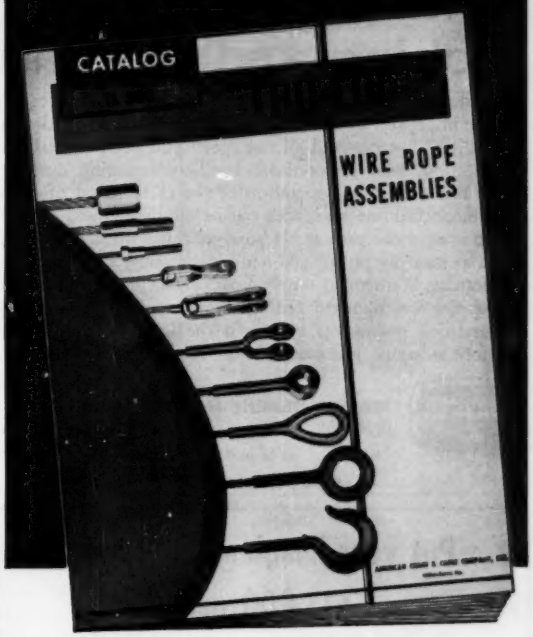
FREE REFERENCE CATALOG

Tru-Loc Wire Rope Assemblies



Standard Tru-Loc Assemblies provide compact, efficient connections at less cost!

• Use this 28-page reference catalog to help simplify many tough design problems. See the variety of Tru-Loc Assemblies possible with Preformed wire rope and swaged fittings. They cut costs, simplify assembly, save space and improve the appearance of products. Send for your **FREE** catalog today and find out how one or more of these assemblies will fit your specific requirements. Catalog contains photographs, engineering drawings, dimensions—and it's all been clearly condensed and charted for easy reference.

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Please forward my free copy of your New 28-page catalog **TL-500** on Tru-Loc Wire Rope Assemblies

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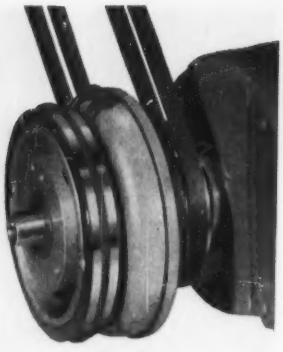

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clutch
for

inching and jogging

Any machine on which inching and jogging are important can be improved by a Warner electric clutch. If you already have "jog" buttons and all the speed you need for hairline positioning, how about those auxiliary actuating devices? With direct electrical operation of the clutch, cost of these maintenance-prone nuisances can be eliminated and control made even more precise. If your machine must be jogged from awkwardly positioned hand levers, now is the time to modernize. Warner can supply a packaged clutch-pulley drive which fits any standard NEMA motor without engineering or machine costs—lets you inch the load by pushbutton without stopping the motor. Write for Catalog P-52.

WARNER **Warner Electric Brake & Clutch Co.**
Beloit, Wisconsin

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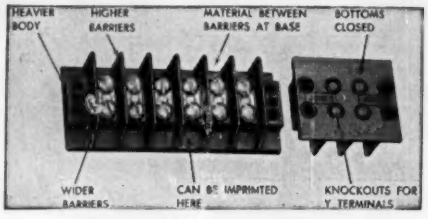

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WANTED: Mechanical Engineer. We need a man with a lot of drive who can design machinery, then follow it through the shop and make the installation in the customer's plant if necessary. We design and manufacture special machinery—mostly ceramic machinery, and our business is nationwide. We are in Western New York State, near metropolitan and vacation areas. The education and recreational facilities are excellent. Contact personnel manager, A. J. Wahl, Inc., Brocton, New York.

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Published by
THE PENTON PUBLISHING COMPANY

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

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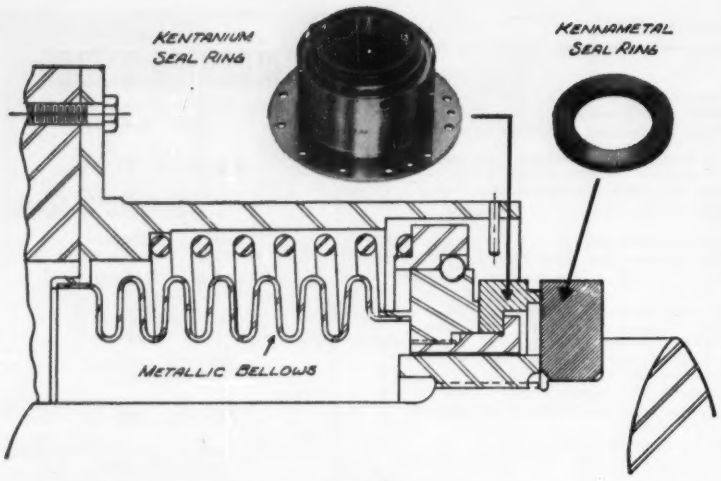

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It's What's Up Front in ORBIT!

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SPHERICAL BEARING ROD ENDS

All seven of them . . . carry the weight and complete all linkages in the "Orbit Seven" Quarter midget Racer

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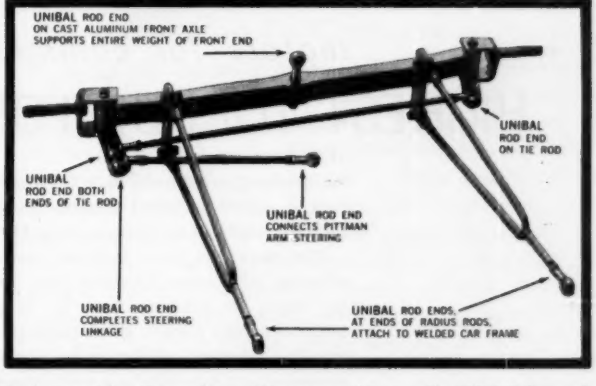
UNIBAL ROD END ON CAST ALUMINUM FRONT AXLE SUPPORTS ENTIRE WEIGHT OF FRONT END
UNIBAL ROD END ON TIE ROD
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UNIBAL ROD END CONNECTS PITTMAN ARM STEERING
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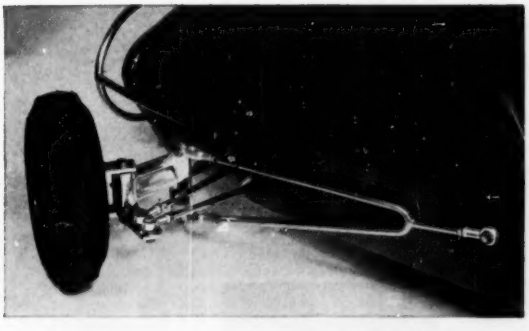

Engineered for the safety of its young drivers, the "Orbit Seven" Quarter Midget Racer uses Unibal Rod Ends at both ends of the tie rod, at both ends of the steering rod, at the rear ends of the radius rods where they connect to the frame, and in the center of the front axle to support the front end and permit fully adjustable caster and axle setting for any track conditions.

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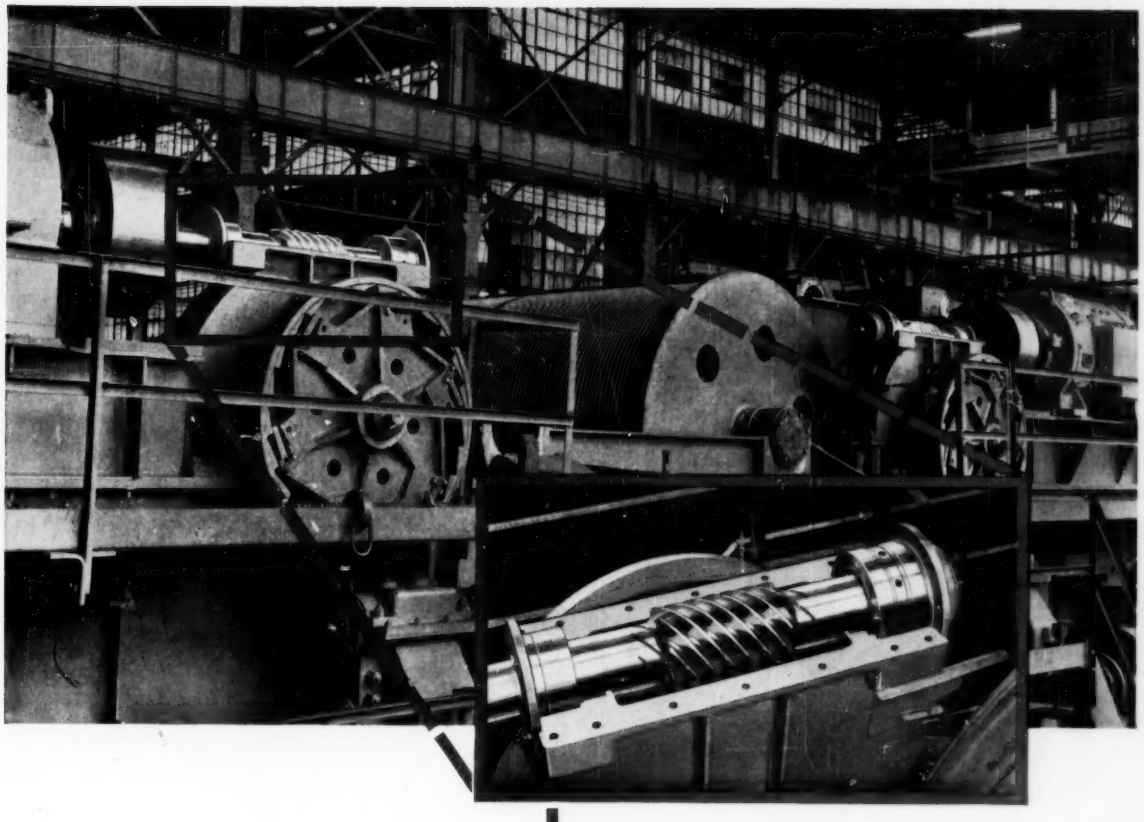

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